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A Training Ship for the Russian Volunteer Fleet

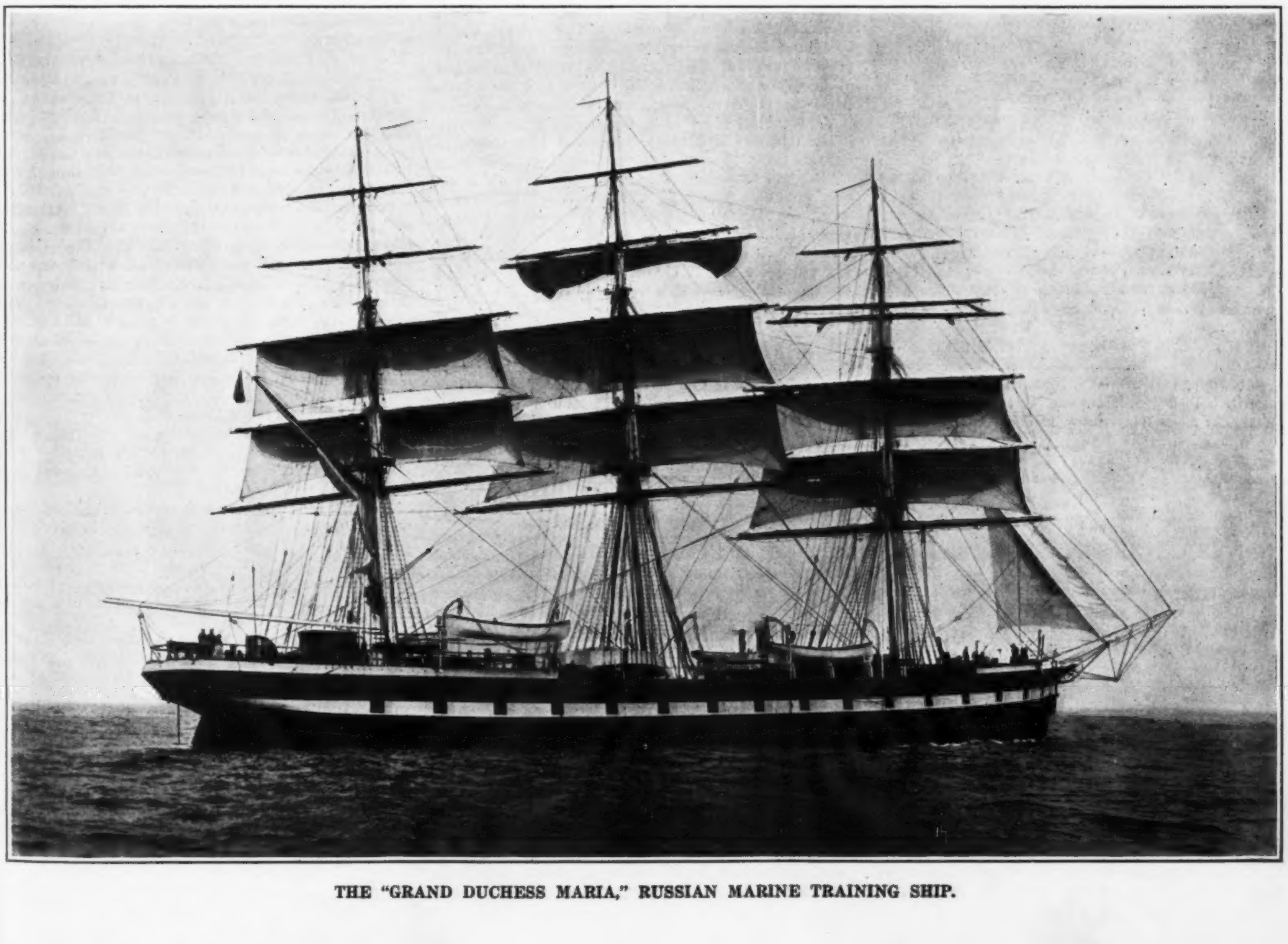
From English Docks to Russian Service

By F. C. Coleman

When the bold proposal was made to build ships of iron the objection was quickly forthcoming that to build a ship of thin plates of this material and send her out on to the high seas to endure the insidious action of salt water upon her structure, would be to court a disaster which might be delayed, but must come, inevitably. These prophets of evil did not realize, or had quite forgotten, the protective ability of the paint brush. There are good staunch ships afloat upon the seven seas today, whose years of service are longer than the years of some of us who have already passed the prime of life. Here and there, now and again, they who are so fortunate as to have a taste for the historical side of things nautical, and have an eye that can detect under a new name, and possibly a new rig, the well-known lines of some famous ship of heaven knows how many decades ago, occasionally come across a rejuvenated sailing ship, whose spick-and-span appearance might mislead the casual observer to thinking that her years of life and service were no greater than the number of letters in her name.

We have heard much lately about the disappearance of the old-time sailor, the thoroughly qualified man-before-the-mast. The substitution of steam for sail power is responsible for this; but there is a small measure of satisfaction in the thought that several of the large shipping companies have built or refitted ships for the express purpose of giving to boys the necessary training to enable them to develop into seamen who will possess, if not the experience, at least a considerable part of the necessary knowledge of the sailor of an earlier day.

A finely-modeled three-masted iron ship, built at Greenock in 1873, which under the name of "Hesperus" was famous in her day for the rapid voyages made between this country and Australia, has just recently left the Tyne for Kronstadt, having been entirely reconstructed to serve as a ship for training boys to become seamen in the Russian marine service. The vessel has been re-entered into Lloyds classification under the name of "Velikaya Knyashna Maria Nikolaevna" ("Grand Duchess Maria") and is now controlled by the Russian Volunteer Fleet Association of St. Petersburg. The leading dimensions are: Two hundred and sixty-three feet long, 39 feet 6 inches broad, with a depth of 23 feet 6 inches. Her gross tonnage is 1,925. The whole of the weather decks from stem to stern and also the 'tween decks were stripped and entirely renewed. The complicated rigging of the vessel has also been renewed. Several new spars and yards on the fore and main masts have been provided and a complete set of new yards on the mizzen mast. The ceiling in all the holds has been replaced at the forward end of the ship and a new teak deck house on the poop. The steel top-gallant bulwarks have been made good and new teak rails added. An entirely new set of boats has been supplied. The steam windlass, capstan, and winches have been renewed and an additional donkey engine installed. A deep tank, with a capacity of 1,000 tons of water, has been put into the ship, fitted with suitable pumping machinery for rapid discharge. In the 'tween decks accommodation has been made for 240 cadets and 35 seamen. Capt. Balk, the commander of the vessel, is quartered in very commodious apartments in the poop, which is 74 feet long. Adjoining the saloon are a luxurious sitting room, and a reception room. In addition to the captain's quarters in the poop there are cabins for the four officers, six instructors, and two doctors. The petty officers are quartered in the forecastle. The engineers and doctors' assistants have their apartments in the forward deck-house. An installation of electric light and steam heating has been fitted throughout the ship. Refrigerating machinery and cold storage rooms have been provided as an addition to the commissariat department. Carefully-designed fire-extinguishing apparatus has been put into the ship, and to complete the needs of modern times wireless telegraphic apparatus has also been installed, so that the craft is fully equipped in every detail.



THE "GRAND DUCHESS MARIA," RUSSIAN MARINE TRAINING SHIP.

Cold in Nature and in Science

Extremes of Temperature in Cosmic Space and in the Laboratory

The distinguished physicist, Charles Nordmann, contributes to a recent number of the *Revue des Deux Mondes* an article which contains much of value, though a portion of it, being intended evidently for readers with little scientific knowledge, is too elementary for our own columns, and another section deals with the cryogenic laboratory of the Dutch physicist Kamerlingh-Onnes, which has already been much more fully described in our pages.

We quote from the remainder of the article:

"Physicists have created recently a whole series of substances of temperatures almost unimaginably low, which, after having singularly enlarged our ideas upon matter, may shortly actually revolutionize industry.

"What would become of the bodies which surround us if the temperature were lowered gradually through a great number of degrees? We know that the vapor of water when cooled first condenses into a liquid and then solidifies into ice. It is the immortal honor of Lavoisier to have first perceived, by one of those intuitions which often precede by a century the results of experiment, that all the bodies of the universe act like water.

"'If the earth,' wrote Lavoisier on a prophetic page, 'were suddenly removed to very frigid regions, Jupiter or Saturn, for example, the water which to-day forms our seas and rivers, and probably most of the liquids we know, would be transformed into solid mountains and very hard rocks. The air, or at least a portion of the substances that compose it, would without doubt cease to exist in the state of an invisible fluid, for lack of sufficient heat; it would return to a state of liquidity, and this change would doubtless produce new liquids of which we have no idea.'

". . . . Around the sun, whose average temperature exceeds 5,000 deg. Cent., are scattered the planets, receiving more or less heat according to their distance. . . . Taking the distance of the earth from the sun as a unit of measure we have this table:

	Distance from Sun.	Temperature Deg. Cent.
Mercury	0.39	+ 158
Venus	0.72	+ 53
Earth	1.00	— 4
Mars	1.52	— 48
Jupiter	5.20	— 153
Saturn	9.54	— 184
Uranus	19.18	— 210
Neptune	30.05	— 223

"The figures given are only approximate. Thus, the average temperature of the earth is higher than —4 degrees, the average temperature at the surface being nearly +15 deg. Cent. This difference is doubtless largely due to our blanketing atmosphere, and similar effects are probably found on the other planets.

". . . . The lowest natural temperature recorded on the surface of the earth is —72 deg. Cent., once observed at Verkhoïansk in Siberia (where there reigns an average temperature of —40 degrees in January). . . . .

"It is probable that the exploration of the antarctic continent will reveal temperatures still lower. . . . At the winter station of the Framheim, though it was more than 10 degrees from the pole, Amundsen found the annual mean temperature to be —25 degrees with a minimum of —59 degrees on August 13th, 1910. (We must not forget that the austral winter corresponds to our summer.) Reasoning by analogy we must conclude that at certain points on the planets most distant from the sun there must reign temperatures much below —200 deg. Cent."

We omit the explanation of the meaning of the absolute zero, i. e., —273 deg. Cent., with which we assume our readers to be familiar. It is worth noting, however, that there is an increasing tendency to drop the minus sign and write 273 degrees A. to indicate the freezing point of water.

THE ATTACK ON THE ABSOLUTE ZERO.

"The history of the attempts of savants in the past hundred years to approach as closely as possible the *pole of cold* has all the features of an epic. It has its heroes and its martyrs; it is full of thrilling episodes and of exploits whence new exploits continuously spring, until the day when, but a short while ago, having succeeded in liquidifying the most refractory of gases, helium, this astonishing liquid was seen boiling at less than 271 degrees below 0 deg. Cent., at less than 2 degrees from the inaccessible goal.

"It has long been known how to obtain temperatures many tons of degrees below zero by means of refrigerating mixtures, a method invented it is said by the Chinese. . . . . With a simple mixture of ice and salt it is easy to get —20 degrees; we can go as low as —50 degrees with a mixture of ice and calcium chloride, but this does not satisfy physicists. . . . . Water boils at 100 deg. Cent. at ordinary atmospheric pressure. If the pressure be lowered the boiling occurs at a much lower temperature. . . . . If the pressure be augmented the temperature of ebullition is raised; this happens in boilers.

Thus, for example, at 10 atmospheres water does not boil until 180 degrees, at 200 atmospheres not until 365 degrees. So it is possible to melt tin or even lead in water!

"The ebullition of water cannot take place until the tension of the vapor is equal to that of the atmosphere into which it escapes; and this at once explains the preceding facts. . . . . When water is partly evaporated it is much cooled, or at least the transformation cannot occur without a lively absorption of heat. This is why one feels cold on coming out of a bath and why very volatile liquids, such as ether, alcohol, and ammonia produce a sensation of cold when a small quantity is poured on the skin. . . . . Hence, in lowering the pressure above a boiling liquid we lower the temperature. But if the idea of Lavoisier is correct the bodies we consider as gases are merely vapors of liquids boiling at very low temperatures, which cannot exist in a stable state at ordinary conditions of temperature and pressure. Hence, we can obtain artificial cold by liquefying these gases by compression and then letting them evaporate. In fact compression is the agent which keeps the water in our boilers in the liquid state at temperatures much higher than the normal boiling point.

"It is thus that we have liquefied chlorine, sulphurous acid, carbon dioxide (which at ordinary temperatures becomes liquid at a pressure of 36 atmospheres) and a great number of other gases. Obviously the process is facilitated by plunging the compressing apparatus into refrigerants.

"However, the idea of Lavoisier seemed refuted for a time by the resistance of five gases, oxygen, nitrogen, hydrogen, methane and carbon monoxide, to which helium and fluorine have been more recently added, to liquefaction by compression, and these have therefore been known as *permanent gases*. Submitted to pressure even of 2,800 atmospheres they remained absolutely rebellious, until the discovery of the *critical point* taught us the reason for this check.

"The critical point is a characteristic temperature of each body above which it can not exist except in gaseous state, however formidable the pressure.

"Brought to its critical temperature any liquid whatever is suddenly gasified without change of volume, e. g., the critical temperature of oxygen is —118 deg. Cent. below zero and that of helium is —268 deg. . . . . Above —268 deg. Cent., therefore, it is too warm for helium to be other than gaseous, and the temperature at which it boils is always lower than this.

"To liquefy these refractory gases, therefore, it is only necessary to cool them below their critical points before compressing them. This is no easy thing; but we arrive at it by two different means. The first proceeds from the discovery of Cailletet that a gas compressed slowly and then expanded *suddenly* is much chilled. . . . . To give an idea of the cold produced by this process we merely recall that M. Cailletet by compressing the air under 300 atmospheres in a thick glass tube by means of a column of mercury forced into the tube by a simple hydraulic press, then suddenly releasing the pressure by opening a cock, saw the air, brought thus much below its critical temperature, instantly resolved into a thick fog. It is by this simple process that the permanent gases were first conquered.

"The same result was attained shortly after, by another process, the idea of which, and the successive improvements, are due to divers savants, among whom may be mentioned Pictet, Olzewski and Wroblewski, and finally Kamerling-Onnes, the Dutch scientist who is the conqueror of helium."

This process has been described in detail in previous issues of the Scientific American Supplement and we therefore pass on to the results.

. . . .

"Helium itself, supreme triumph, was liquefied by cooling it by means of hydrogen boiling in a vacuum and then expanding suddenly after having compressed it to 100 atmospheres. It presents itself as a colorless, transparent liquid boiling at —269 deg. Cent. in the air.

"Unless a still more refractory gas should be discovered, there is scarcely any possibility of approaching nearer the absolute zero than Kamerling-Onnes has done. Indeed, so nearly has this point been approached that for ordinary purposes it would be but a slight stretch of the term to say that it has been reached.

. . . .

CONSERVATION AND PROPERTIES OF LOW TEMPERATURES

"To study at leisure the properties and physical effects of these astonishingly cold substances which the so-called permanent gases become when liquefied, it is important above all to be able to manipulate them in the open air. It might be feared that this would be very difficult or impossible because of their rapid evaporation. . . . .

"Ice itself is very hot compared to liquid air boiling in air at —193 deg. Cent. Throwing a bit of ice into a flask containing this liquid a violent ebullition is produced, a trick which always astonishes popular audiences.

"However these liquefied gases have been successfully preserved in the open air a very long time by an ingenious device of M. d' Arsonval and Prof. Dewar, which consists of inclosing them in receptacles formed of a double envelope of glass inclosing a vacuum between its walls and having its interior surface silvered.

"The vacuum prevents the exterior heat from being transmitted to the liquid by conduction. The silvering prevents its being transmitted by radiation. . . . . Thus we can isolate thermally the liquefied gases and liquid air in particular, so that on their exterior surface there will not be deposited the slightest trace of frost from water vapor in the air. The vacuum and the silver coating maintain, therefore, between the two walls separated by a distance of less than 5 millimeters, a difference of temperature close on 200 deg. Cent.! When dealing with liquid hydrogen, which boils in the air at —200 deg. Cent., or with helium, we also take the precaution to immerse the double-walled receptacle in a bath of liquid air. . . . . It suffices to remove the plug closing such a receptacle holding liquid hydrogen, to behold the surrounding air condensing at the edge in the form of a frost formed of solid air!

"Most of the refractory gases present themselves, when liquefied, in the form of colorless and transparent liquids like water, or, if solidified as white snows or translucent ices. From this point of view hydrogen surprised the savants, who from its properties had been led to consider it rather as a metal than as a non-metal. In both liquid and solid states it is light and transparent and lacks the ring of metal.

"Oxygen is not colorless, but of a pretty blue color, even in a layer of slight thickness. Liquid air has a bluish tint increasing in depth with the proportion of oxygen. While it is not certain that a body has the same color in the solid as in the gaseous state, it is nevertheless true that this at once suggests an explanation of the phenomenon of the blue color of the sky.[1]

"Low temperatures modify the properties of matter in the most surprising fashion. Chemical affinities are greatly diminished by intense cold, and seem rendered sluggish. To take only one example: Potassium, which at ordinary temperatures has such an affinity for oxygen that it will seize it by decomposing the water into which it is plunged, may be plunged with impunity into liquid oxygen. Photographic action becomes one fifth as rapid at —180 deg. Cent.

"There are, to be sure, one or two exceptions, such as the explosive combination of solid fluorin with liquid hydrogen.

"It is well known that oxygen is magnetic, though in a less degree than iron. Thus it has become possible to extract the oxygen of the air by means of a simple magnet!

"A large number of common substances, flowers, fruits, rubber, etc., become fragile and brittle at these temperatures. Steel entirely loses its elasticity; on the other hand its resistance to traction is augmented to such a degree that at —180 deg. Cent. an iron wire can support a weight double that which will break it at ordinary temperatures.

"But the most astonishing physical effect of cold is without doubt its action on the electric properties of metals. A copper wire of given dimension and diameter presents less resistance to the electric current than an equal one of iron, and less also than a smaller one of copper.

[1] This blue color can however be accounted for in other ways.

This is expressed by saying that copper has a greater conductivity than iron. This conductivity is enormously increased with cold. At —180 deg. Cent. it is five times as great as at ordinary temperatures; at —250 deg. Cent it is 100 times as great; at the temperature of liquid helium *10 million* times.

"Cold in contracting bodies lessens the intermolecular intervals; and it is probable that at the absolute zero, these being reduced to zero, conductivity would be infinite. Thus, cold opens to us new perceptions of the very essence of the elementary particles which compose the world. It remains for us to show how it acts upon life itself, that of plants and animals, and that also of societies, which it will perhaps one day revolutionize.

"And we may imagine that after some millions of centuries, when the cold dead sun rolls its dark orb about a yet darker heaven, that rivers and seas of liquid air, cascades of oxygen and nitrogen tumbling over rocks of carbon dioxide will bathe this insignificant celestial sphere which erstwhile was the ephemeral pedestal of mankind."

The Human Eye and the Photographic Camera*

Points of Similarity and Points of Difference

By Dr. A. Gleichen

Everyone understands that there is a close analogy between the human eye and the photographic camera.

But the analogy is not perfect, and the question therefore arises, how closely it is possible to reproduce by the aid of the camera the appearance of objects around us as they present themselves to the eye.

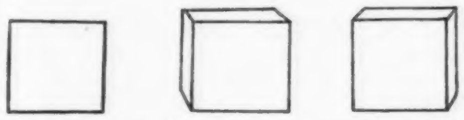


Fig. 1.—A cube may assume a variety of different aspects according to the position of the observer.

To answer this question let us first of all look a little more closely at the processes by which sight is established. Just as in the photographic camera an image of the external world is formed upon the focusing screen by the lens, so in the eye the lens forms an image upon the retina. But, though this fact ordinarily escapes attention, it should be remarked that we do not really see things *as they are.* Our sense of sight opens up to our consciousness the world of forms and colors, while the sense of touch gives us information regarding the form of bodies, the character of their surface as regards such qualities as hardness, smoothness, temperature, etc. Thus the two senses, sight and touch, combine and complement each other to impart to us our representations of the form of bodies. But the two kinds of representations thus obtained are essentially different in character, and it is only through long experience that we are able to fuse into one whole the various impressions obtained by us. Then, for example, if we feel the edges and surfaces of a cube with our fingers, we become aware of its symmetrical shape, the equality of its edges and angles, etc. This is in a way a very complete and truthful representation to our senses of the properties of the cube. But the representation of a cube given to us by our sense of sight is very different. In some positions it will appear as a square, as in the first diagram of Fig. 1. In another position it will look like the second and yet in another like the third. However we may place the cube, *to our eyes* it can never be made to appear like a *symmetrical solid* figure. A being endowed with the sense of sight alone would have an entirely false conception of space. The fact is that the sense of sight depicts the external world entirely *upon a surface.* In this respect the eye is quite similar to the photographic camera. To make matters plain, consider Fig. 3. If *A, B, C, D, E* are a number of different points *anywhere* in space, i. e., in general *not* lying in *one plane,* their representation by the photographic camera will appear, say, at *a, b, c, d, e,* points upon the focusing screen, which are found by drawing straight lines from *A, B, C, D, E to the plane of the screen* through a certain point *F,* which we may for our present purposes speak of as the center of the lens of the camera. Very similar conditions exist in the case of the eye: A three-dimensional world is depicted, point by point, upon a two-dimensional surface, the retina. However, as we are accustomed from infancy to this peculiarity of our sense of sight, we instinctively construe this two-dimensional image as representing a three-dimensional thing, and do not even realize that in doing so we have to supply, by our imagination, certain data which are in point of fact lacking in the picture presented to our eyes; namely, the depth or distance from the observer, of the objects viewed. How dependent we are upon the supplementation of the sense of touch and previous experience, in construing what we see, is proved by the example, occasionally observed, of a person who has acquired sight only in late life. In one such case the first effect upon the patient was to bewilder and even frighten him, when he found all his preconceived notions of the shapes of things—based upon his sense of touch—so completely upset. He was in fact so affected—the report tells us—that he at first looked upon his newly-acquired sense as a misfortune rather than a great gift.

As regards their rendering of perspective, the human eye and the camera are similar, so long as we consider only a small field of view. But, whereas in the camera a considerable field—right to the edge of the plate or film—appears sharp, in the eye only the central portion, and quite a small portion of the retina receives a sharp image. This seeming defect of the eye is made up for by the great mobility of the eye. One result of this is that, while in the photographic camera straight lines are reproduced upon the focusing screen as straight lines, in the eye they are rendered as slightly curved circular segments. This difference, however, rises to significance only in the case of wide fields of vision. Thus, for example, a person looking at a long row of houses, by running his eye along them, obtains such a view as that presented in the upper diagram of Fig. 2. A photographic camera, on the other hand, would give a representation corresponding more nearly to the lower diagram.

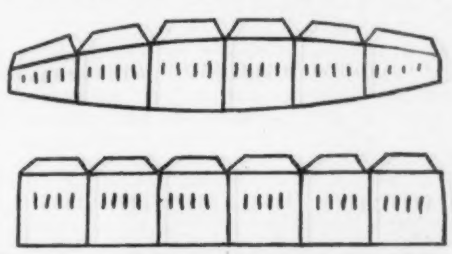


Fig. 2.—A row of houses as it appears to the eye (above) and to the camera (below).

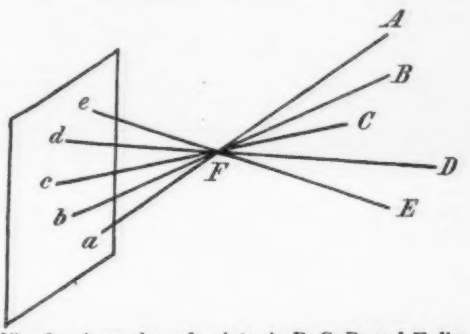


Fig. 3.—A number of points A, B, C, D, and E distributed at random in space are, by the camera, represented by corresponding points a, b, c, d, and e all in one plane.

Another difference between the camera and human sight is that the latter is normally based upon the use of two eyes. Hence, the observer obtains simultaneously two views of any near object, and this, owing to the well-known principle of the spectroscope, gives a certain three-dimensional quality to vision, at least in the case of near-by objects. At a distance of about 300 yards and beyond, however, the "stereoscopic" effect is practically *nil,* and at such distances as these our sense of depth in space is based entirely upon the effect of perspective.

If man had a third eye, he could obtain a still more perfect stereoscopic perception of space. This effect can actually be realized. For, although it is impossible to give a man such a third eye, we can take a triple set of steroscopic views, using three separate cameras. Two of the views so obtained can then be united by presenting them in rapid alternation to one eye, while the third is shown by the aid of an ordinary stereoscope to the other eye. A similar method can evidently also be employed to make stereoscope vision accessible to a one-eyed person.

If we view with both eyes a plane surface, such as a printed page, both retinas receive identical, i. e., not stereoscopically related images. The eye construes the effect with its stereoscopic faculty, and becomes aware of the fact that it is viewing a plane. For this reason photographs, as ordinarily taken, fail to give a realistic impression of the scene which they represent. But of this I shall have more to say in a later article.

* Abridged translation from *Prometheus,* prepared for the Scientific American Supplement.

The Corrosion of Iron and Steel*

By William H. Walker

It is now six years since the electrolytic theory in its developed form was offered as a basis for the explanation of the corrosion of iron and steel, and it seems worth while at this time to inquire into the accuracy of some of the conclusions to which it has led, as viewed in the light of present experience.

In the first place we have found that the factors controlling the rapidity or extent of corrosion are by no means so simple as they were at first thought to be. Many conditions which were considered of little or no importance have been found to exert a profound influence upon the reactions involved. For example, samples of iron and steel exhibiting marked differences in corrosion exposed in the normal condition in which they came from the mill, fail to show any difference upon exposure, when they are first planed to a uniform surface. Apparently the mechanical strain to which the samples are subjected in the planer, masks or neutralizes the difference in corrosion inherent in the normal material. It is not surprising, therefore, that many conflicting results have been obtained and published from the investigators now interested in this work. Only those tests which have been carried on under identical conditions of surface finish, temperature, access of oxygen and moisture, general atmospheric conditions, etc., should be given any weight, and even when the greatest care is taken, generalizations must be drawn with caution.

One of the conclusions reached by a consideration of the electrolytic theory of corrosion which has proved misleading, is that homogeneity in the material insures protection, while heterogeneity leads to rapid attack. While this is a corollary which may be logically drawn from the electrolytic theory and is doubtless in itself true, there are evidently other factors which superimpose themselves upon those due to differences in structure, producing a final effect contrary to that predicted. The iron of the old chain bridge at Newburyport, Mass., has withstood corrosion in a truly remarkable manner for the last 98 years; and yet it is conspicuous for its heterogeneous structure. Large areas of perfectly pure iron, free from both carbon and slag, are mixed up with areas showing at least two kinds of slag, and very high carbon; yet all withstand atmospheric corrosion. On the other hand Burgess has shown that iron free from all contaminating elements which could segregate or produce a lack of uniformity, does not withstand rusting so well as the same iron to which has been added a little manganese or copper or nickel. This behavior is observed also in the case of the so-called pure irons made in an open hearth furnace, which are relatively free from carbon, manganese, sulphur, and other constituents prone to segregation, which have come to the writer's notice. While theoretically a very pure iron should withstand rust, there are apparently some factors present which more than offset any advantage inherent in purity. Obviously conditions affecting the surface of the material so soon as rusting has started are important causes which have largely been overlooked and which demand more thorough investigation.

The most important advance in this field made in recent years, is a knowledge of the effect of the addition of small amounts of copper to normal open hearth or Bessemer steel. The present writer has within a week inspected with much interest test roofs and can testify to the remarkable effect shown. While panels of Bessemer and open hearth steel containing the ordinary amounts of metalloids have entirely failed, the corres-

* Paper read before the New York Section of the Society of Chemical Industry and published in its journal.

ponding panels made from these same heats of steel but to which a small amount of copper was added are in a remarkable state of preservation. A panel of the so-called pure iron very low in metalloids, but containing one half the amount of copper carried by the less pure steel is less attacked than those steels containing no copper, but is much less resistant than are those to which 0.2 per cent of copper was added. Had copper been omitted entirely from this iron it would doubtless have succumbed even earlier. While these tests do not show that any steel, however poorly made, will, with the addition of copper, withstand atmospheric corrosion, they prove that it is the copper, and not the absence of manganese and the other "impurities" which is the controlling factor. Several hypotheses have suggested themselves as explaining this marked effect of copper in causing steel to resist atmospheric corrosion, but as yet none is sufficiently tangible to afford a working theory.

Rapid progress has been made in acquiring that knowledge of the relation of pigments and finished paints to corrosion which is necessary to a better protection of iron and steel. Predictions founded on theory that a basic paint, or one containing a chromate pigment would inhibit rusting, while one made up from lamp black or graphite would accelerate rusting, have, in the main, been found correct. The effect of the pigment upon the character of the oil film making up the paint, however, has shown itself also to be very important. Many basic pigments, such as basic lead carbonate or zinc oxide, which in themselves inhibit, do not withstand the weather; lamp black and graphite, on the other hand, make a very impervious and highly resistant paint film. The logical conclusion in protecting iron is, therefore, to use a basic priming coat, a second coat of a mixture of a basic pigment and a little lamp black, and when well dried out to apply a lamp black or graphite finishing coat. Experience has shown also the importance of brushing the paint well on to the iron; a good paint may fail on account of poor application.

Careful tests with galvanized work show that an even coating of zinc is the all-important factor. The common practice of clean wiping galvanized ware is fatal to durability, since the protecting layer is not metallic zinc, but a thin deposit of a zinc-iron alloy. While therefore much has been accomplished in the way of making a more resistant base, there is still a necessity for a uniform substantial coating of spelter over the entire surface of the material.

Moving Picture Records of a Building in Construction

Machinery Hall, at the Panama-Pacific Exposition, the World's Largest Wooden Building

Moving pictures have been employed for a variety of useful purposes, as well as for the ubiquitous entertainment theatre. An interesting development of rather novel character is being applied on the building site of Machinery Hall at the Panama-Pacific Exposition.

Details in the construction of this hall are being recorded by a moving picture machine set to take a picture automatically every five minutes. The camera is placed upon the roof of the Service Building, one of the completed exposition structures, and has an inclusive view of the new structure.

Under the magic influence of the "Movies" a full grown building will be conjured up, beginning with the bare ground and finishing in eighty minutes with a structure completed to the topmost pinnacle. Like the Temple of Solomon it will be built without the sound of a hammer.

The records will show ninety-six pictures for each working day or a total of 6,912 for the three months required for completing the building. When the pictures are reproduced the reel will be run at the rate of 864 pictures per minute, or more than a week's progress in one minute.

This is a new departure from the usual custom of taking photographs of buildings at different stages of construction, and aside from the interest of the picture it will furnish the exposition officials with a valuable record of the building operations as they expect to study the effectiveness of various methods of construction through the slower reviews of the films.

Machinery Hall will be the largest wooden building in the world; more than seven million five hundred thousand feet of lumber will be used in its construction, and more than four carloads of nails; twelve hundred tons of steel and iron will be used. The dimensions of the building are 967 feet long, 367 feet wide, extreme heights 135 feet, with three great naves running throughout its length.

The ground for the building was broken on New Year's day, 1913. The contract is let for completion of the building in 248 days. A record has been made in the assembling of the structure, which will be fully completed in every detail well within the specified time.

The illustrations which accompany this note are selected plans showing various stages in the progress of the work.

Fig. 1.—Grading the foundations and digging the sewers for Machinery Hall.

Fig. 2.—A week later. Part of the timber hauled into place for the construction.

Fig. 3.—The framework being assembled on the site of the great building.

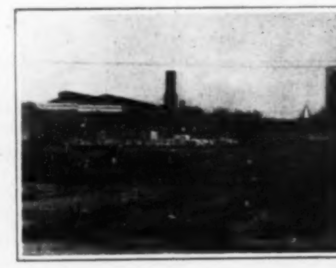


Fig. 4.—A week later. Many of the trusses have been removed to other portions of the site.

Fig. 5.—Derricks used to lift the trusses and girders into place.

Fig. 6.—A giant crane is employed to assemble the building.

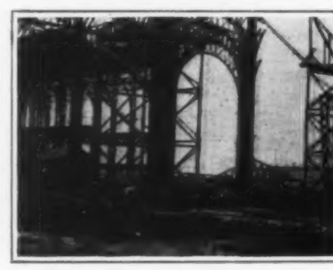


Fig. 7.—Further progress is made on the trusses of the framework.

Fig. 8.—As the trusses are developed the building assumes form.

Fig. 9.—Side of Machinery Hall, showing the building in advanced construction.

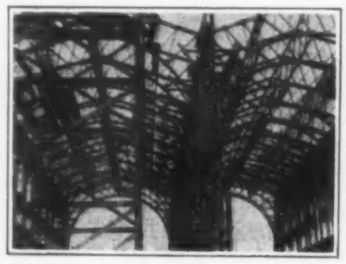


Fig. 10.—A section of the arched trusses forming the framework of the roof.

Fig. 11.—The erection of the building is like the weaving of the filaments of a spider's web.

Fig. 12.—View taken at the north end of the building at a late stage in its development.

The Intrinsic Brilliancy of the Glow Worm*

Nature Fifty Times as Efficient as Our Best Artificial Light

By Herbert E. Ives and C. W. Jordan

[The most important facts in an illuminant are efficiency and intrinsic brilliancy. The latter must not be so high as to injure the eye, nor so low that sufficient light cannot be secured without using a prohibitive amount of wall space. The intrinsic brightness of the glow worm is found by measurement to be of a practicable magnitude, so that both from the standpoint of efficiency and of intrinsic brilliancy its light is worth attempting to copy.—Editor.]

A single fire-fly does not give much light. Perhaps this fact explains the comparatively small interest taken, until recently, in the fire-fly as an illuminant. The first requirement of the uninformed is for a big bright light. Compared with a gas flame, an incandescent lamp or even a candle, the ordinary fire-fly is hopelessly outclassed. It is true that in tropical countries cages of fire-flies are sometimes used as lanterns, even giving enough light to read by, but for all that, not bright enough to have ever suggested to the non-scientific that here lay the future mode of light production. The casual observer has not been the only one to be accused of superficiality in this matter, for we find scientific investigators measuring the total candle-power of a fire-fly flash, as though that were a vital figure. It would be vital if our hope were to use the fire-flies themselves as light sources and if we had to calculate the number of thousands necessary to light a room, just as we now calculate the number of units of ordinary illuminants.

The significant elements of any illuminant are two in number: First, efficiency, and second, intrinsic brilliancy. The efficiency of the fire-fly is fifty times that of our ordinary illuminants. From that standpoint there can be no question that fire-fly light is well worth striving to copy. The second factor, brightness per unit of area, has apparently not been directly measured. Its importance is evident upon a moment's thought. The candle-power of a light, be it incandescent lamp or lampyris beetle, is dependent on its size. If the most efficient and desirable illuminant in the world occurred in a 1/1000 candle-power unit, it might be rejected by the hasty as useless, when all it needed was to be made larger. Yet the 1/1000 candle-power might be given by 1/1000 of a square centimeter of area, so that one square centimeter would light a large room. On the other hand it might be that neither a few square centimeters nor as many as would completely cover the ceiling, walls and floor of a room would furnish enough light to see by. In which category does the fire-fly fall? What is its candle-power per square centimeter, its intrinsic brilliancy?

One difficulty of such measurement lies in the intermittent character of the fire-fly light. The fortunate finding of some larvæ of the fire-fly (*Photurus Pennsylvanicus*) which gave a steady unwinking light of the same character as that of the matured fire-fly, made it possible for us to get some figures in a very simple manner. It was noticed that the light-giving portion of the insect, located on its abdomen, could be so turned as to lie on the extreme edge of its profile. If, then, the worm was held in front of large bright area this luminous spot together with the background formed the two parts of a simple photometric field. The complete scheme is illustrated above. *A* is the glow worm held between thumb and forefinger; *B* is a white diffusely reflecting surface illuminated by the standard lamp *C*, whose distance from *B* is adjustable. In spite of the difference in color, the settings were easily made. The only difficulty we experienced was that the glow worm, apparently displeased at the pressure put upon him, would sometimes turn low or extinguish his light, which he had under as perfect control as is a gas flame. Nevertheless, a number of readings were secured corresponding to the light output.

The value directly obtained was, of course, the illumination of the white diffusing surface against which the glow worm was viewed. The surface we used was white blotting paper which under an illumination of 190 meter candles matched the example of organic luminescence. The coefficient of diffuse reflection of white blotting paper is given as 0.76. We therefore have the following equation from which to calculate the candle-power per square centimeter:

$$\frac{190}{\pi} \times 0.76 \times \frac{1}{10{,}000} = B.$$

When worked out this gives 0.0046 candles per square centimeter.

Compare this result with the 164 of a tungsten filament, or even the 0.3 of a typical sky. At first glance, it appears low, but upon due consideration it will be found not too low for practical purposes. We must bear in mind that the great majority of our artificial lights are of altogether prohibitively high brightness, so that it is necessary to reduce this brightness by the use of diffusing glassware or of reflecting surfaces. Our ideas of what is normal in intrinsic brilliancies have been

Method of measuring the light of a glow worm.

molded by the amount of diffusion it is possible to obtain with the means at hand. The best way to learn whether the glow worm light could be used for illumination or whether like most cases of chemical light as distinguished from incandescence, it is altogether too dull for such a purpose, is to calculate how much of it would be needed in order to light a given room. In passing it may be remarked that a white surface illuminated to 190 meter candles is much brighter than we are accustomed to have our working planes or reading pages. Suppose the problem were to secure 25 meter candles illumination on a working plane 2 meters below the light source. This would necessitate a 100 candle-power unit, approximately two square meters of light source. When properly placed a 100 candle-power unit gives adequate illumination for a room of many times 2 square meters floor space, certainly as much as five times that area.

This calculation is made on the basis of the light furnished by the glow worm under natural conditions. By various kinds of stimulation its brightness may be much increased. The flash of the fire-fly is probably many fold, perhaps fifty or one hundred fold, as bright as the steady glow of the larva. Such conclusions have been drawn with respect to the adequacy of the intrinsic brilliancy which we measured, hold of course for the higher brightness attainable with the same insect under more intense exertion.

It appears then that the luminous material of the glow worm, could it be reproduced, would not only be of high luminous efficiency, but would also be a happy mean in intrinsic brightness, far lower than the artificial light sources with which we now try our eyes, yet high enough to permit its use without pre-empting more wall space than we now give to windows.

* Reproduced from the *Lighting Journal*.

Improving the Quality of Aluminium*

Aluminium is a very useful metal, although it is so comparatively new to us; but like other metals it has its faults, which we seek to neutralize by alloying it with other materials, since the action of heat upon it does not effect any desirable changes therein, as is the case with steel.

Among the experiments that have been made in the way of alloying are those with cobalt, the results of which have not become very generally known, and which are especially interesting when the action of this alloy is increased by the addition of tungsten and molybdenum.

Scientific researches into the chemical relation of aluminium and cobalt in alloy form go to show that those two metals are so to say soluble in each other. Of the various alloys that have been made and studied, the one with the least percentage of cobalt had one third of this metal therein; its solidifying point being somewhat above 100 deg. Cent. Between this compound and aluminium there is a "eutechtic" containing only 0.5 per cent of cobalt, and having a melting point lower than that of pure aluminium. There is also in the curve showing the melting points of the aluminium-cobalt alloys, a decided kink at the point corresponding to 20 per cent of cobalt.

With 9 to 12 per cent of cobalt there are obtained alloys that are almost free from bubbles, although the fracture is somewhat coarse and crystall ne; and although the tensile strength is not much above that of pure aluminium the alloy is more readily turned and polished, etc., and much more resistant to atmospheric influences. These alloys are still quite light and much more workable than pure aluminium. The lack of tensile strength is due to the coarse crystalline fracture, but this may be improved by the addition of tungsten (which the Germans call "wolfram") and molybdenum, so that by the help of these an alloy with but a small percentage of cobalt has three times the tensile strength of aluminium, and is also malleable and ductile. These alloys run about 0.8 to 1.2 per cent tungsten, 8 to 10 per cent cobalt, the rest aluminium.

The more cobalt these alloys contain, the less readily can they be rolled, but the greater their tensile strength; so that those with high cobalt percentage are better for castings, the poorer ones better for forging and rolling. The alloys of molybdenum, cobalt and aluminium run from 0.6 to 1 per cent molybdenum, 9 to 10 per cent cobalt, the rest aluminium; these follow about the same general rules as those of wolfram, cobalt and aluminium, except in the matter of hardness, in which they are inferior to the corresponding tungsten-cobalt alloys.

The Study of Atmospheric Electricity is carried on much more actively in Germany than in any other country. A joint commission on this subject has been established by several German academies of science, and the recently published report of its meeting held last year in Munich constitutes a document of much interest to physicists and meteorologists, as an example of the latest views and activities of experts in this somewhat neglected and highly specialized field of science. The report is entitled "Protokoll der Sitzungen der luftelektrischen Kommission der kartellierten deutschen Akademien zu München am 24. und 25. Mai 1912," and is published by the Bavarian Academy of Sciences.

* From *The Metal Industry*.

The Principal Causes of Injury by Electricity

The Extent and Nature of the Contact is Often of More Significance than the Character of the Source

The tremendous and continually increasing development of the applications of electricity, both for industrial and for domestic purposes, has unfortunately been accompanied by a parallel increase in the number of injuries and deaths due to accidental electric shock.

Such catastrophies are peculiarly horrible because of the uncanny nature of a fatality which differs from others in being attended usually neither by the flow of blood nor by outcry on the part of the victim, and because the same mysterious, silent force too often lies in wait to attack would-be rescuers.

Yet many of these accidents could easily be prevented by a few simple precautions which are not taken merely because of ignorance.

This ignorance it is the design of a timely article in *Die Naturwissenschaften* to remedy. The author of the paper, Dr. H. Zangger of Zürich, writes:

"The conditions under which an electric shock, i. e., the passage of a current through the human body, occurs, are of decisive significance as regards the total effect in the case of ordinary tensions, especially those of electric light wires.

"It is precisely these conditions, little known to the laity, which modify the effect that we here investigate, particularly since the ascription of the danger to the wires alone and a neglect of the importance of the other conditions lead to numerous accidents.

"Let us, to begin with, briefly summarize the ordinary physiological circumstances which occasion a severe shock. A certain electric tension (voltage) must be present, because the body itself offers a great resistance to the passage of the current (usually through the superficial layer of the skin), and because a fatal effect occurs only when those organs are involved wherein the interruption of function is followed by instantaneous death, as the heart, the brain, and the upper part of the spinal column.

"Sensitiveness to the electric current is of varied degree in the animal kingdom, being greatest in men.

"In most cases in adults it seems to be the fact that when the heart is affected a definite quantity of electricity can disturb or check the rhythmical heart-beat by which life is maintained. This quantity is about 0.05 amperes for the average of the whole body. From this it results that when the bodily resistance is only about 1,000 ohms, and outer surface is thoroughly moist, the electric current is capable of being dangerous at a tension of 50 volts and upward.

"Why is it, then, that so few accidents occur although we have in our houses electric light wires of 100 to 250 volts tension? Because, in the first place, when we touch such a wire we touch it with only a small portion of the outer surface of the skin, and, secondly, because we usually stand on substances that are bad conductors of electricity. *The current can flow through the human body only when it finds both a place of entry and a place of exit.*

"The larger the surface of contact of the skin with the conductor the greater the amount of current which can enter, just as more liquid can flow through a big pipe than through a little one under the same pressure.

"The same thing holds true for the area of the surface of exit.

"In standing and walking the soles of the feet and the foot-covering form the place of exit. Even at low tensions an accident may happen, if, for instance, a person stands barefoot on a piece of metal which has a connection with metal running into the earth, as for example, gutter-pipes, cranes, iron rails, etc.; while there is much less danger when one stands on dry wood, rubber or glass

"However, the object on which the feet immediately rest is not that of conclusive significance It is rather a question of what *layers* of material the current must penetrate before it arrives where it can readily dissipate itself, as in damp earth or a system of wires or pipes.

"Here, too, a comparison with the flow of water makes the conduct of electricity easier to understand. While greater quantities of water can flow through a large pipe under a given pressure, the absolute quantity of the flow will be largely reduced when there are narrow or constricted intervals in the pipe, since great resistance is thus introduced. In electric conductors, layers of glass, rubber, dry wood, linoleum, or any narrow layers of so-called insulation, correspond to such constricted passages. On the other hand larger quantities of electricity will traverse damp objects and metallic conductors to reach the earth.

"To estimate the total effect, therefore, we must consider what is the total sum of all resistance between the human body and the conductor whence the current enters, and also the sum of those between the body and the earth.

"*This is because the greater the sum of all the resistances, the smaller the quantity of electricity which passes through the body.*"

It is obvious that different conditions as regards such resistance are apt to obtain in the case of the hands and of the feet.

"We are accustomed to take heed not to touch an electric wire with either hands or head, because such measures of precaution are sufficient for ordinary life. They take into account the fact that the air offers strong resistance, and that usually it is easy to avoid such contact. Such precautions are not generally necessary as regards the feet, and moreover it is not always possible for us to keep the feet on insulated materials.

"But the relation of the feet to the earth or some other good conductor may be of decisive importance at the moment of a chance contact, of the upper part of the body, for example, with an electrically charged conductor. Thus, in all cases of accident from electric light wires it is commonly found that the fatal effect was produced when the victim was standing on damp earth, especially on *salt-containing* damp earth, or when he touched with his bare feet an iron kettle, a lightning-rod, a metal water-pipe, a gutter, or something similar."

Some striking and informative examples are given in this connection, as when a roofer slipping touches an iron plate or a gutter with his bare feet and at the same moment tries to save himself by grasping an electric light wire; or when a wire falls and a man climbs up on a radiator to replace it, having one hand on this metallic object with an earth connection and holding the wire in the other. . . . In such cases the current enters through one hand, traverses the chest, passes through the broad contact surface of the other hand into the metal conductor and then into the earth. A contributory circumstance is that the act of grasping increases pressure and area of contact, hence, there is less resistance to the current so that relatively large quantities of electricity may pass through the body even at a low tension Analogous conditions were those in the case where a workman standing in a kettle filled with a salt solution and changing an electric lamp, touched the brass socket.

Especially dangerous situations are those in which a large portion of the body is enveloped by a liquid conductor, as in baths with a direct drain pipe. In such cases the resistance to the exit of the electricity is so small that a very small surface of contact with a charged conductor, as a defective light wire, may lead to serious disaster."

The author continues:

"Statistics give particularly high percentages of fatal accidents in those industries in which the ground is damp and likewise rich in soluble salts.

"In general the fatalities in which a lowering of the resistance is the decisive element are far more numerous than those due to a temporary heightening of the tension in a low-tension system (such as lighting systems), which may occur through high-tension wires falling on low-tension wires. or when atmospheric electricity is discharged through such systems.

"In very exceptional cases, on the other hand, a contact with 5,000 volts may be entirely harmless, e. g., when 2 or 3 meters (6 to 10 feet) of frozen snow is found among mountains, in which case a high-tension conductor may be touched with impunity. This is an extreme instance of protection by insulation of the feet, for pure frozen water and snow in such thickness are extraordinarily good insulators.

"For the same reason contact with high-tension currents is usually harmless in balloons, though of course even in a balloon it would be dangerous to touch two phases of an alternating current, or wires of two different systems.

"Even in a 'strong current' (500 volts or more) *resistance* is the decisive feature.

"Above all it must be borne in mind that the essential effect is conditioned by the nature of the organ involved (heart, brain), and that very great currents can traverse the body when these organs are not in the circuit (as when the current passes from leg to leg, or down the right side of the back, right leg, right arm and shoulders) without endangering life."

"Numerous accidents occur when temporary buildings and scaffolds are erected, especially when iron poles are erected, which may come in contact with lighting systems. Firemen also may come in contact with high-tension currents through streams of water.

"Interesting and important are those accidents which occur on railroads when electric traction is used. Thus it has happened that the firemen of steam locomotives running on such lines may touch a conductor with one of their long-handled implements. . . . Such injuries could be avoided by sufficient knowledge.

"In a different class are accidents which occur to men familiar with the whole plant, and which are peculiarly uncanny, since they depend on imperfect reliability of materials and plant, and therefore contain elements of grave warning. Against mechanical chances, such as the breaking of wires, precautions have increasingly been taken, as against atmospheric discharges and those coming from long distances. Thus, long conductors which are in course of repair are divided into sections which can be disconnected.

"One of the most subtle dangers lies in the instability and alterability of the resinous insulation materials, since they are mostly colloidal substances whose inner structure becomes altered, and altered indeed more rapidly than that of any other material used in construction.

"It is particularly influenced by changes of temperature and action of light and is sensitive to alternating current and direct current.

"Experience shows that the dielectrics composed of resin and analogous colloidal substances are specially attacked by the alternating current at the start, while in the case of the direct current it acts later on these isolators, especially when they are permanently or temporarily surrounded by liquids, so that electrolytic decompositions by the direct current can occur.

"The huge consumption of these insulating masses, has caused an enormous number of substitutes to be tried, so that to-day in most cases we do not know just what mixture was made use of for a given insulator.

"One is exceedingly apt to forget that it is just these apparently dead *safety materials* that are the most unreliable in the whole electric plant, just because they consist of mixtures of chiefly organic colloidal substances which are sensitive to a very large number of affecting causes.

"Another danger, which did not arise so long as only one electric plant was present in any given neighborhood, is of late largely on the increase. . . . Through the great number of 'groundings' in cities it now happens that such terminals of very different tension are often found near each other, so that not seldom currents from a high-tension system pass into the earth and become the source of serious accidents. Since the earth is not always of such composition as to disperse considerable quantities of electricity within a short distance, dangerous shocks may be received in the neighborhood of such terminals even without direct contact with the conductor.

"Thus animals have been killed who stood with their fore-feet in the vicinity of terminals in badly conducting earth. In one case all animals who trod on a large iron bridge fell dead when an ordinary electric light wire was grounded there."

This important paper is brought to a close by a discussion of the dangers which may lie in wait for children, men, or animals bathing in streams whose water has become charged with electricity in some adventitious manner, drawing a moral from a very shocking fatality which occurred (July 15th, 1912) when three boys of

six, eleven and fourteen years were instantly killed on going to bathe in a brook near which was a small electric plant. The plant, formerly direct current, had for about a year made use of a three-phase alternating-current of 3,000 volts and 30 to 40 kilowatts. The brook is from two to three yards wide with a depth of 50 to 70 centimeters (20 to 28 inches). The boys died without a cry, and the workman who chanced to observe them felt a shock when he entered the water in an effort to save them. Investigation proved clearly that the water had become charged from the plant in question.

The writer says: "It is requisite for an electric shock that one part of the body shall be under high tension and another part under a lower tension or one of opposite nature. It is, therefore, necessary that a source of electricity should exist somewhere and that it should pass through the water, and, therefore, that different potentials should occur in the water. From traces of burning in the transformer station and in the generating house it was concluded with certainty that a large quantity of electricity had passed through the ground wires and this precisely at the time the accident occurred, and this was registered by the instruments in the 'central' at this hour."

Space forbids us to give all the details, but enough has been said to put both engineers and property-owners on their guard against such shocking possibilities of catastrophe. In this case it was a mere chance, moreover, that fifteen or twenty children were not killed instead of three.

Electrodes for Electric Furnaces*

Some Points in Their Proper Design and Manufacture

By G. Basil Barham, A.M.I.E.E.

For some reason in electric furnace work, not only the actual electrodes themselves, but also the end connections which are used to connect the cables from the supply to the heating resistance are frequently termed electrodes, although this term could only be applied in the correct sense to these terminals when the resistance was of an electrolytic nature. Generally speaking, the name is given to the carbon or metal bodies which, together with the charge, form the primary essentials for almost every form of electric furnace yet devised.

The best material for electrodes from the point of view of conductivity is graphite. Usually ordinary carbon is employed, as all forms of carbon decrease in resistance as the temperature to which they are heated increases, being in this respect the exact opposite of most of the so-called rare metals, such as those used for lamp filaments. Carbon, further, can be raised to a higher temperature than can any other substance suitable for use as electrodes. Unfortunately at high temperatures it will readily enter into combination with certain metals, tungsten and molybdenum in particular, forming carbides. Carbon electrodes at high temperatures also act as reducing agents unless they are properly cooled, and it may be said that the problem of effectively cooling electrodes without allowing heat to flow from the hot end of the electrode to the exterior of the furnace is not an easy one to solve. If metal electrodes are employed in order to avoid the troubles which may result from the use of carbon, they also must be effectively cooled or they will dissolve or volatilize. When metal electrodes are used it is customary to form them of similar metal to that about to be treated, so that should any part of them be dissolved, the smelted metal would still be in its original form and not in that of an alloy. It will be remembered that Ferranti, Heroult and Kjellin devised means whereby the work of smelting could be carried out without electrodes or without such electrodes as were used coming into actual contact with the metal which was being dealt with.

It has been mentioned that one method of preventing the escape of heat to the outside of the furnace is by cooling, but it will be evident that much depends on the proper proportioning of the electrodes themselves to the current which will be passed through them, and by which the interior portion is raised to the required temperature. This question was thoroughly gone into a short time ago, and it was found by experiment that many of the rules formerly used for designing electrodes were quite incorrect. It was proved that current density was not a determining factor in the design of these parts, and that the resistance was determined by the conditions and not to be considered as merely a matter of choice. The conditions determine either the length or the section of the electrode, and it is only the ratio of the section to the length which is the determined factor. Neither the thermal conductivity nor the electrical resistivity is a governing factor, but it is their product and quotient which are the true measures of the qualities of electrodes. The quotient of the thermal over the electrical conductivity is proved to determine the loss, while the product of the two resistivities determines the proportions, hence it is not necessary to know either one or the other of these properties, but only their quotient and product. It was furthermore shown that these are more easily determined than the others. These two quantities lead to some new quantities not hitherto used, but by means of which the calculations of electrodes become simple in the extreme. These two quantities are termed the loss and the size factors.

Hering has tabulated these for each of various temperature ranges. The loss factor, called "watts per ampere," when multiplied by the current, will give the loss in watts directly, while the size factor, called "section per ampere per square inch," when multiplied by the current and by the length, gives the cross-section in square inches.

A problem, which has been the subject of considerable attention, has been in regard to the terminal connections to the electrodes. It appears useless to clamp the electrodes into metal holders, or to use clamping bands, plates, couplings or caps. The metal expands much more than does the carbon as the temperature rises, with the result that the metal attachment works loose, and local heating, which may have disastrous results, sets up. A metal rod, carrying a terminal attachment, can be used for the purpose, one end being mortised or sunk into the carbon electrode. It is important, however, that this should not be too tight a fit, as otherwise, when the metal expands, it will burst the end of the carbon rod or block. In one form of terminal a metal rod, which is enlarged at its bottom end, is passed into a hole in the carbon which has been undercut, so that while it is large inside, the mouth of the hole will only just permit the thickened end of the rod to pass. When the thick end of the rod is pushed to the bottom of the hole, thin metal plates are slipped down beside it, with the result that when an attempt is made to withdraw the rod, the plates jam it in place. This makes a sufficiently good electrical connection, and one further which allows of expansion, the metal rod sliding slightly down the inclined plane made by the metal strips, as it expands under the heat conducted through the electrode.

Common coke, as obtainable at any gas works, is quite suitable for electrodes in the majority of circumstances, and has the advantage of costing but little. In the production of calcium carbide, aluminium, or carborundum, such electrodes answer the purpose admirably in every way, especially if the coke is first picked over, and the light and more porous portions removed. A good carbon for low-tension work is made of a mixture of 25 per cent of gas coke and 75 per cent of petroleum coke. This latter is a by-product of the oil distilleries, and at one time was the only kind that was largely used in the manufacture of carbons for electrical purposes. The only other constituent for the best quality of electrodes is pitch, obtained from the distillation of tar. A common pitch obtained from blast furnaces, but which is far from pure, being contaminated with iron compounds, can be used, but it is not nearly so suitable. At the same time it is not easy to get the desired quality of pitch from the distilleries. The quality depends on the freedom of the pitch from anthracene oils, as when it contains these it is what is technically termed "wet," an expression the meaning of which is self-evident. To get it properly dry all the oils must be driven out, and few still owners care to expose their plant to the high temperatures, which have to be kept up for a long period, in order to drive off the whole of these oils.

In the manufacture of electrodes the coke is first crushed to the size of coarse gravel, after which it is heated to incandescence in a sealed retort, which is provided with a few vents to permit occluded gases to be driven off. After withdrawal from the retorts the coke is ground to fine powder and conveyed into storage bins. The pitch is first broken by hand and then passed through machines which break it up into fine granules. The coke and pitch are then accurately mixed, and it is on this mixing that the quality of the resultant electrode depends. It is carried out in a cast-iron cylinder containing an independent shaft, which is fitted with arms which drag the material from the sides of the drum as fast as it is thrown there by centrifugal action, and bring it back to the center. After undergoing this treatment for some time, the mixture is spread out and allowed to solidify, after which it is again broken up and pulverized in a mill. It is then finally pressed into molds, which are the shape of the required electrodes, and baked to render the pitch-coated particles of coke thoroughly adhesive. As soon as the required degree is reached the mold is placed in a hydraulic press, and a pressure of several hundred tons brought to bear upon it.

* Reproduced from *The Electrical Review*.

Utilization of Waste Raisin Seeds

A Government bulletin entitled, "The Utilization of Waste Raisin Seeds," has recently been issued by the Bureau of Plant Industry. It is based on an investigation which proved that the seeds removed from raisins yield technically useful products that fully justify the expense involved in separating them.

In the raisin-seeding industry, which in recent years has grown to such proportions in California, vast quantities of seed accumulate annually. From 30,000 to 40,000 tons of raisins are seeded every year, and it is estimated that there should be in the neighborhood of 3,000 to 4,000 tons of the seed available annually. The utilization of this waste has received some attention by the producers in recent years, but thus far with little success. It appears that a brandy has been made by fermenting the sugary matter that adheres to the seeds, and that a high-proof alcohol has been distilled after the fermentation. It is also reported that some fixed oil has been obtained from the seeds.

The investigation described in the bulletin showed that four important products can be obtained from the waste seeds, namely, syrup, fixed oil, tannin extract, and meal. If the entire annual output of 3,000 to 4,000 tons of seed were used there would be obtained 550 to 740 tons of syrup, 340 to 460 tons of fixed oil, 330 to 445 tons of tannin extract, and 1,600 to 2,200 tons of meal.

Commercially the manufacture of syrup could be accomplished with comparative ease. Owing to the solubility of the sugars in water the process of preparation resolves itself into simple extraction and concentration. A clear transparent syrup with the characteristic flavor of the raisin can be produced from the sticky seeds. Its uses are many and should justify its production.

After washing off the sugary matter and drying and screening the seeds, they need only be ground for the production of the fixed oil. Two methods of extraction are feasible—by pressure and by solvents. The clear amber-colored oil is useful in paint and soap manufacture and possibly in other industries.

After the preparation of the syrup and the extraction of the oil from the seeds, the extraction of tannin is recommended. As the tannin is soluble in water it can be extracted in a practical way by boiling the meal in large digestion vats, the solution being transferred to vacuum pans for concentration to a moist extract. If a dry extract is preferred it can be obtained by simply allowing the moist extract to dry in the air.

The final residue—the meal—possesses useful qualities. While possibly it is not equal to some of the standard press cakes and meals for stock feeding, yet on account of its high protein content its usefulness as part, at least, of a stock-feeding ration can hardly be denied.—*The Chemical Engineer.*

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A New Laboratory for Research in Optics and Photography

Devoted Primarily to Industrial Problems, It Will Publish Also Data of General Scientific Interest

With the developing organization of industry and the increasing application of the results of modern scientific investigation to manufacturing processes, it has become more and more necessary for all manufacturing businesses to maintain a well equipped and adequately staffed laboratory for the solution of its technical problems, as well as for the improvement of its products. But a few of the more far-sighted organizations have realized that something more than this is required if the future progress of the industry is to be directed by the manufacturing organization itself instead of being left to chance developments arising outside the industry, and for this reason a few firms have established laboratories whose primary business is not the solution of works problems, or the development of better products, but the fundamental investigation of the scientific bases on which the industry rests, together with the relations of the industry to all cognate sciences. Such laboratories, which are in the strictest sense of the word research laboratories, engaged in investigation and not in production, are becoming more and more necessary with the specialization of industry and the increasing concentration of technical knowledge in the manufacturing organization itself. It is well known for instance that no thorough technical training in dye-chemistry can be obtained outside the dye-works, and the same is true of many other industries, which have a vast fund of technical information, partly written and partly traditional, which is unpublished and is almost entirely withheld from the academic world; so that it is largely to the specialized laboratories which have inherited this technical knowledge, that we must look for progress in the scientific organization of industry. Many of these research laboratories have become world-famous; the scientific staff of the Zeiss Works has made Jena one of the chief centers of optical research for the last 30 years, and the publications from that works would form a goodly portion of all contributions to applied optics, while the research laboratories of the great Ge man dye-works have not only developed the practical industry in the making of artificial coloring matters, for which they are so famous, but have been directly responsible for the greater part of the written information on dye chemistry which is accessible to the outside world.

A research laboratory of this character, intended for investigations on the photographic process, and on the physics and physical chemistry of photography, has just been built and equipped by the Eastman Kodak Company, in Rochester, N. Y.

In research on the photographic process, more perhaps than any other branch of scientific industry, the investigator who is not associated with a manufacturing company is at a disadvantage, because he is investigating the properties and behavior of finished products of whose manufacture he knows very little and his results must be influenced by any change in the manufacture, which necessarily would not be communicated to him, while at the same time he will not be in a position to try experiments as to the variations in the properties of products which can be effected by changes in their preparation. It is so necessary for the research laboratory to be in a position not only to make its own material for investigation, but to make experimental material on a comparatively large scale, that the company, in designing their new laboratory have provided for a special manufacturing plant situated in the laboratory itself and capable of making photographic products on a scale commensurate with that employed in the manufacturing departments of the plant. The laboratory is in a position to make photographic plates, films, and papers, and after the measurement of their properties to make further experiments on such a scale that the results obtained can immediately be applied to the manufacturing departments of the company. At the same time there can be manufactured in the laboratory on a small scale products for which there is only a small demand for use in special scientific investigations, so that any photographic material which is required for scientific work, and the method of preparation of which is known, can be supplied to investigators by the laboratory without involving the cost which the manufacture of such a small quantity would entail in one of the large departments.

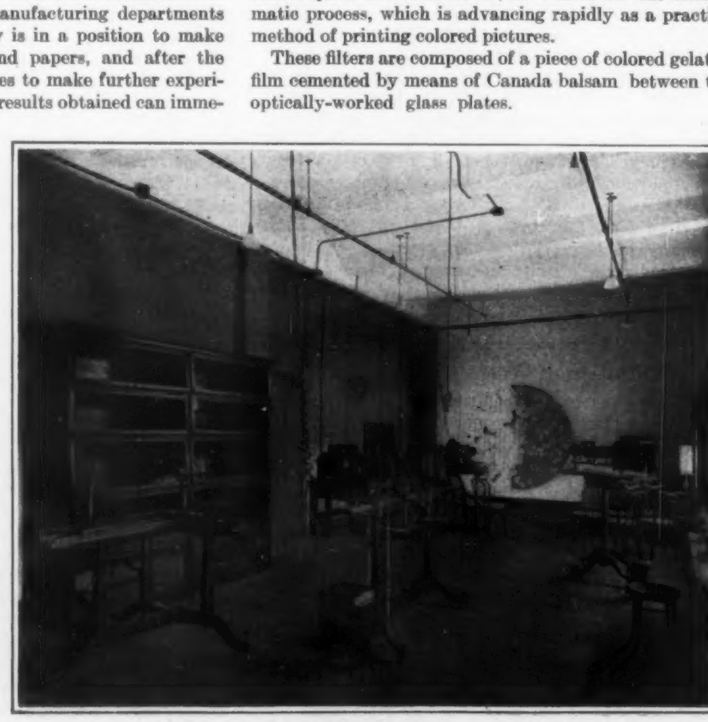
The laboratory is located in the midst of the immense manufacturing plant where the products of the company are made; it consists of a steel-frame building 80 feet square and three stories high, having, in addition, a basement the full size of the building, which houses the machinery for the manufacturing equipment and gives room also for the emulsion department where experimental emulsions, for plates, film and paper can be prepared.

On the first floor are rooms provided with the necessary machines for the coating and packing of dry plates. In these rooms an amount of plates equal to that made in an average small dry-plate factory can be coated and packed every day, and it is here that the panchromatic dry plates, sensitive to all colors, for which the Wratten & Wainwright Company are famous, will be made. In another section is a machine for coating either film or paper in sufficient quantity for extended practical trials.

In addition to the panchromatic dry plates it is intended to manufacture in the laboratory the colored light filters which are required for the correct reproduction of colored objects in monochrome, as well as for the trichromatic process, which is advancing rapidly as a practical method of printing colored pictures.

These filters are composed of a piece of colored gelatine film cemented by means of Canada balsam between two optically-worked glass plates.

The spectroscopic laboratory.



The projection room.

The gelatine film is first made by coating on glass a strong solution of gelatine to which the necessary dyes have been added. After drying the film is stripped from the glass and the color tested by the measurement of its absorption for different parts of the spectrum, in an instrument known as a spectrophotometer. About ninety different standard colors of filters are made. To make a finished filter the film is cemented between the glass plates and the whole dried slowly and evenly. The filter is then tested for its optical properties, such as the degree of distortion which it might introduce into the image formed by a lens, and only the perfect filters are permitted to pass. The instruments used for this optical testing have been specially designed for the purpose and are interesting illustrations of applied optical theory.

Next to the filter department and just inside the main door of the laboratory accessible to the whole technical staff of the company, is the library. Occupying a room 51 feet long and 21 feet wide and covering the whole range of chemistry, physics and engineering, in addition to photography, this library is in every way worthy of the laboratory and of the company.

The second floor of the laboratory is entirely given up to scientific work. In addition to a suite of offices including a conference room, where regular meetings are held for the discussion of specific problems, this floor contains the physical and physicochemical laboratories.

The physical laboratories consist of a spectroscopic laboratory, with a dark-room attached, a general laboratory, a photometric room, and a dark-room for the absorption photometers.

The work to be undertaken here consists of the measurement of the optical properties of the eye and of the photographic plate and includes photometry, sensitometry, spectroscopy and colorimetry.

A large part of the work to be done in these laboratories will be concerned with the exact investigation of the sensitiveness of photographic emulsions and of the phenomena relating to their exposure and development. It is intended to attempt to standardize a fundamental unit of light for use in photography and for this purpose the photometric room has been fitted with a large bench photometer and the most accurate type of standard lamps. These are electrical standards which have been checked against the international standards, the current and voltage being controlled by potentiometers of the highest precision. Arranged in such a way that it can be used with the lamps on the photometer bench is a new type of precision sensitometer by which photographic materials can be exposed to a measured source of light for various accurately known periods of time.

By means of this apparatus it is intended to investigate with the maximum accuracy attainable the relation between the intensity of the light, the time of exposure, and the blackening obtained after development.

Another series of measurements of interest to all who employ photography for scientific purposes, are those which it is proposed to make on the power of different emulsions to render fine detail. For this purpose various types of instruments are used, one taking the form of a long tube, at one end of which an object is placed, consisting of a transparent glass having fine lines upon it, while at the other is a very rigid camera fitted with a lens giving excellent definition.

The spectroscopic laboratory is fully equipped with instruments, the largest being a Rowland grating spectrograph, of the Littrow type in which the beam passes from the slit through a lens, which renders it parallel, and then falls on the grating, which reflects it back through the same lens so that the spectrum falls upon the photographic plate placed just below the slit. For work with ultra-violet light there is a large spectrograph with quartz lenses and prism, while two other spectroscopes are specially designed for the measurement of the sensitiveness of photographic products to the spectrum, and of the absorption of light of different wave-lengths by colored solutions or filters.

In addition to the optical instruments intended for research, the physical laboratory has a full equipment of electrical measuring instruments by which all measurements can be directly checked against the international volt, ohm and ampere.

The physico-chemical laboratory is arranged for the investigation of the properties of colloids, and for the physical measurements involved in research on electro-chemistry, exact analysis and chemical statics and dynamics.

Corner in the process studio.

A large portion of the time of this laboratory is to be devoted to an investigation of the properties of gelatine, which is of such fundamental interest to the photographic industry.

The room is fitted with large thermostats for the maintenance of constant temperature as well as with a particularly complete and convenient installation for electrical measurements and electro-analysis.

It is intended to devote a good deal of attention to the physical chemistry of development, with a view to obtaining a clearer view of the reactions that occur and of the influence of the composition of the developing solution upon the course of development.

The third floor is devoted more especially to photographic work, in front are two large studios with north light, one of which is fitted with a process camera arranged for the making of the three-color screen negatives, for which the panchromatic process plates are made.

Opposite this room is the X-ray room, with its walls and floor covered with thick sheet lead, and a screen of lead-covered boards and lead-glass window extending across the room to protect the operator. The generator for the X-rays is a powerful Snook machine capable of the most rapid work. By means of this apparatus a measurement is being made of the effect of X-rays upon various kinds of photographic emulsions, with a view to comparing the effect with that of light.

It is interesting to note that the company has already introduced a series of X-ray films and plates which are being eagerly welcomed by radiographers.

Another important room on this floor is the projection room. This room is 42 feet long, the end of the room giving a white screen 12 feet x 17 feet. In it are instruments for direct and opaque projection, as well as for the projection of spectra and complementary colors and for high-power micro-projection.

A special instrument has been constructed for this room by means of which the absorption curves of very small colored particles can be measured with a combined projection microscope and spectrophotometer.

Another instrument is devoted to the observation and photography of "ultramicroscopic" particles, that is particles which, while too small to be observed by an ordinary microscope, can be made luminous by their reflection of a highly concentrated beam of light falling upon them and so can be observed as shining specks against a dark ground.

To this room is attached a developing room arranged for the development of photomicrographs or the enlargement of negatives, etc.

All the laboratories are piped for hot and cold water, distilled water, gas, compressed air, and vacuum, while the sensitometric rooms have a special acetylene line for the standard burners.

The electrical supply is 220 volt and 110-volt direct current, but the building is also wired for a 4-volt line from a storage battery, intended for use on small stirring motors and on reading lamps attached to instruments.

A 30-cell storage battery supplies current for the standard lamps on the photometer and also for electro-analysis.

In the spectroscopic laboratory alternating current is used for vacuum tubes and spark work, the current being generated by a rotary converter and stopped up by high tension transformers to the required potential.

The results obtained in the laboratory will be published as papers, in the same way as communications from University and Government laboratories, and while the company will naturally use the knowledge it acquires for the development of its business, and for the betterment of its products, there will be no attempt to limit investigations to immediately practical ends, the company being convinced that the best way to obtain practical results by research is to endeavor to attain to exact knowledge of fundamental principles.

Limit of Sensibility of Taste and Smell.—G. H. Parker and E. M. Stabler have determined experimentally that our sense of smell is much more sensitive than our sense of taste.

It was found that grain alcohol was just tasted in a dilution of two-gramme molecules per liter, while its vapor was still detected by the nose in a dilution of one two hundred thousandth of a gramme molecule per liter.

Room for work on light filters.

In the library of the institute.

The Production of Synthetic Ammonia*

The Reduction of Atmospheric Nitrogen by Catalysis

By F. Haber and R. Le Rossignol

AMMONIA in the form of commercial 25 per cent ammonium sulphate possesses a value of 89 Pf. per kilo (9.5 cents per pound), while the nitrogen and hydrogen of which it is composed may be valued at 2½ Pf. and 17½ Pf., respectively (2.14 cents for the nitrogen and hydrogen in 1 pound of ammonia). The nitrogen is preferably obtained from air by liquefaction, as the resulting gas is relatively free from argon. It may also be made by the alternate action of air and producer gas on heated copper. Large quantities of nitrogen are generated as a by-product in the manufacture of formic acid from producer-gas and caustic soda. The hydrogen may be obtained by the decomposition of distillation gases, by the alternate action of steam and reducing gases on iron, by the electrolysis of water, or by the action of water-gas on calcium hydroxide (*Ber.*, [1] 13, 719 (1880)). It is produced in large quantities also in the electrolytic manufacture of alkali and in the manufacture of oxalates from formates. The synthesis of ammonia from nitrogen and hydrogen depends upon the equilibrium represented by the expression:

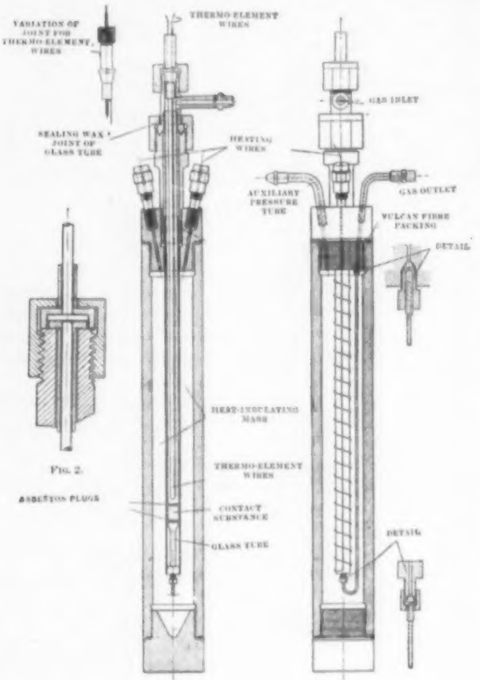


Fig. 1.—Apparatus for comparing the efficiency of catalysers. Fig. 2.—Arrangement for making gas-tight joints for the heating wires.

$$K = \frac{p_{NH_3}}{p_{N_2}^{\frac{1}{2}} \cdot p_{H_2}^{\frac{3}{2}}}$$

where p represents the partial pressures of the respective gases and K is the reaction constant. Haber and van Oordt (*J. Soc. Chem. Ind.*, 1905, 131, 545) have studied this reaction, and found that at incipient red heat, equilibrium is attained when only traces of ammonia have been formed, and even under increased pressure, which favors the formation of ammonia, the conditions are very unfavorable at incipient red heat or higher temperatures. The yield of ammonia corresponding to the condition of equilibrium increases as the temperature falls but the reaction velocity also falls off very rapidly. Haber and van Oordt's results (*loc. cit.*) indicated that in order to be able to work at atmospheric pressure, a temperature of about 300 deg. Cent. must not be exceeded, but up to the present no catalyst has been found which is active at so low a temperature. The most active catalyst found by Haber and van Oordt was manganese, but the present authors have found osmium and uranium to be much more effective. The limits of temperature for practical working are between about 500 deg. and 700 deg. Cent. Above 700 deg. Cent. any advantage accruing from increased reaction velocity is more than counterbalanced by the low yield of ammonia. At a little below 500 deg. Cent. it is possible, at a pressure of 125 atmospheres, to obtain 0.5 gramme of ammonia per hour per cubic centimeter of space in the contact chamber, and since in high-pressure work the size of the apparatus must be limited, it is not advisable to work at a lower temperature and hence with a lower reaction velocity. The results obtained are better the higher the pressure. Curves are given showing that at (1) 100 atmospheres and (2) 200 atmospheres pressure, respectively, the theoretical yields of ammonia at different temperatures are approximately: 500 deg. Cent., (1) 10.7, (2) 18.1 per cent.; 550 deg. Cent., (1) 7, (2) 12.2; 600 deg. Cent., (1) 4.5, (2) 8.3; 650 deg. Cent., (1) 3, (2) 5.8; 700 deg. Cent., (1) 2.1, (2) 4.1 per cent. It will be seen that in no case is the yield so high that it would prove remunerative to absorb the ammonia from the reaction products, and allow the residue to go to waste. A continuous process must, therefore, be adopted, the ammonia being removed and the residual gases, after addition of fresh nitrogen and hydrogen, being again passed over the contact substance. The simplest method of separating the ammonia is by liquefaction by cooling. Temperatures down to —75 deg. Cent. may be used for this purpose, but below —75 deg. Cent. there is risk of solidification of the ammonia, leading to stoppages. The regeneration of heat and cold in gas-liquefying apparatus with gases under high pressure has proved surprisingly efficient. However low the temperature, a certain fraction of the ammonia always remains in the gaseous condition and this fraction is somewhat higher than would be expected from the vapor-pressure table.

The apparatus used for comparing the efficiency of different catalyzers consisted, in its simplest form, of a strong steel cylinder with a bore of 6 or 7 millimeters diameter, opening above into a conical enlargement into which fitted the conical lower portion of a steel cover. A special joint[1] was used here, and also wherever possible in the apparatus described subsequently, the conical portion of the cover having a more acute angle (16 degrees) than the conical portion of the bore (20 degrees); a hollow screw-threaded plug, fitting over a flange on the cover, was screwed on to the upper portion of the cylinder, thus bringing the two conical portions into effective contact. This apparatus was heated by means of a bath of fused saltpeter. Another form of apparatus (see Fig. 1) for comparing the efficiency of catalysts consisted essentially of a thin iron tube (0.6 millimeter thick, 9/13 millimeter diameter) wrapped in asbestos paper and wound with nickel wire (0.4 millimeter thick) so that it could be heated electrically. The contact substance was contained between asbestos plugs in an inner quartz or glass tube sealed at the upper end, in which also was a quartz capillary, inclosing a thermocouple. The lower end of the tube containing the contact substance was flush with the end of the heated iron tube, and the latter was fastened by screwing and soldering to a steel capillary through which the gases were withdrawn The whole was inclosed in an outer strong steel cylinder as shown. In order to prevent deformation of the heated iron tube by the high pressure, an auxiliary pressure tube was provided through which the gas mixture was introduced also into the space filled with heat-insulating material (asbestos paper) surrounding the tube. All joints in this apparatus were of the type described above, except in the case of the plugs closing the outer steel cylinder, and the insulated joints for the electrical heating wires. The joints of the steel cylinder were made gas-tight by means of disks of "Vulcan fiber," and the joints for the heating wires in the manner shown in Fig. 2, the wires being soldered to a small metal plate, about 2 millimeters thick, which fitted into a recess in a disk of "Vulcan fiber" and was covered by another disk of "Vulcan fiber," both disks having central openings through which the wire passed. It is stated that in this furnace, with correct adjustment of the heating coil, a field of constant maximum temperature of 4-5 centimeter length can be obtained. The largest furnace, which was used in the experiments with circulation of the gas, is shown in Fig. 3. In this furnace there is a heating coil in the gas space so that the mixture of nitrogen and hydrogen is heated before it reaches the contact substance, and cools gradually in passing over the latter; the formation of ammonia thus sets in at a relatively high temperature and hence with a high velocity, and further quantities of ammonia are formed during the gradual cooling, owing to the displacement of the equilibrium in a favorable direction. This furnace is also fitted with a heat regenerator, formed by a bundle of 127 steel capillaries, wound with iron wire, and supported by two hexagonal iron plates, perforated as shown in Fig. 3*a*, the capillaries passing through the perforations and projecting a short distance beyond the plate, which is provided with a rim. A powdered alloy of 40 per cent of silver and 60 of copper is melted, with exclusion of air, around the ends of the capillaries and fixes these in position. The bundle of tubes is inclosed in a hexagonal pipe. As shown in Fig. 3, the mixture of nitrogen and hydrogen entering at the bottom of the furnace, flows upward through the hexagonal pipe, along the outer walls of the capillaries, then along the outside of the tube containing the con-

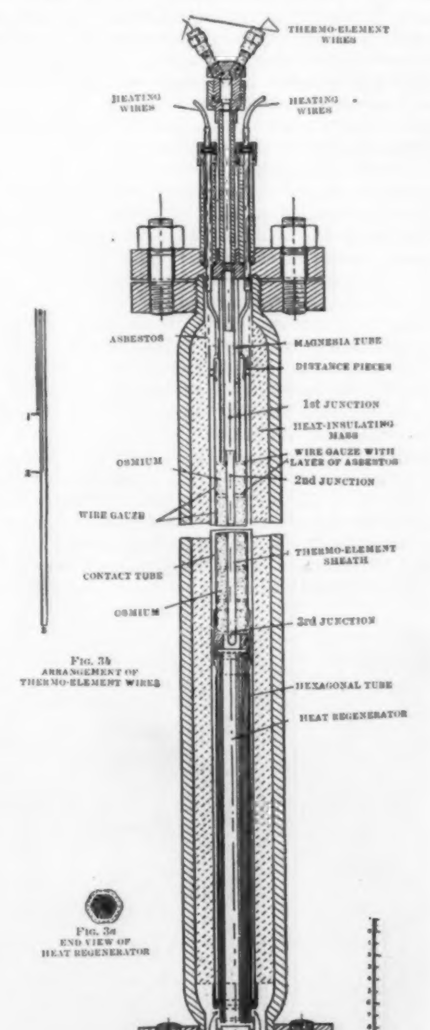


Fig. 3.—Large furnace used in experiments with gas circulation.

* Abstracted by the *J. Soc. Chem. Ind.*, 32, 134 from the *Zeitschrift fur Elektrochemie*, 19, 53 (1913).

[1] D. R. G. M. 376,829 des Laboratoriums mechanikers F. Kirchenbauer.

tact mass, next downward along the outside of the magnesia heating tube, and over the contact substance, and finally through the capillaries of the heat regenerator to the outlet. The magnesia heating tube is of 16 millimeters outer and 9 millimeters inner diameter and 15 centimeters long, and is supported on an iron tube. Inside this is a thin iron tube extending down through the contact chamber and serving as a sheath for the thermo-element, which consists of a platinum-rhodium and three paltinum wires arranged as shown in Fig. 3b. The length of the outer steel cylinder is 75 centimeters, the contact chamber is of 25 millimeters diameter, and the tube inclosing the contact chamber and heat regenerator is of 32 millimeters diameter; the space between the latter and the outer steel cylinder is filled with a stamped-in mixture of *magnesia usta* and finely-divided asbestos. The contact chamber was 25 centimeters long and only a very small part of the space therein was actually filled by the contact substance. The covers of the outer steel cylinder were fastened by means of bolts, the joints being made tight by copper washers; the other joints were made as described before. In the experiments with circulation of the gas, the apparatus was arranged as shown in Fig. 4. A small double-acting steel pump was used, with a stroke of 3–6 centimeters and a piston of 19 millimeters diameter. The piston rods consisted of steel wire, 1–5 millimeter diameter, and the stuffing-box packing consisted of alternate layers of brass and cotton impregnated with paraffin, to a total length of 1.5 centimeters. At 300 revolutions per minute and a pressure of 200 atmospheres, the capacity of the pump was 72 centimeters per hour (at atmospheric pressure and temperature), but the actual amount of gas circulated was somewhat less, owing to the leather packing of the piston proving not quite satisfactory; the stuffing-box packing answered very well. The ammoniacal gases from the furnace pass through a copper capillary to a drier charged with soda-lime and then to a heat-exchanger (cold regenerator) consisting of three copper capillaries united at the inlet and outlet; the capillaries are wound into coils as shown, and are contained in a strong steel cylinder. From the cold regenerator, the strongly cooled gas passes into the liquefier, and the liquefied ammonia is drawn off as necessary; or by opening the outlet valve to a suitable extent, the ammonia could be blown off as a uniform current of gas. The gases leaving the liquefier, pass through the cold regenerator to the pump, and thence again to the furnace, a fresh quantity of nitrogen and hydrogen being added on the way through a valve. Through another valve samples of gas could be withdrawn. For determining the ammonia content of the gas mixture, Rayleigh's gas interferometer as supplied by Zeiss was used, the gas being examined before and after passage through sulphuric acid (compare *J. Soc. Chem. Ind.*, 1906, 802). The results of experiments with cerium and allied metals, manganese, tungsten, uranium, ruthenium, and osmium as contact substances are described.

Uranium.—The commercial metal, broken up with a hammer, was used in a column of 4–5 millimeter diameter and 3–3.5 centimeters long. At about 600 deg. Cent. vigorous formation of ammonia began. At 190 atmospheres pressure and the gas mixture flowing at a velocity of 20 liters per hour (measured at atmospheric temperature and pressure), the issuing gas contained 5.8 per cent of ammonia constantly during 1½ hours. With a velocity of 3 liters per hour at 580 deg. Cent., the ammonia content rose to above 7 per cent and liquefaction of ammonia occurred at the valve. At a pressure of 120 atmospheres and a velocity of 3 liters per hour at 580 deg. Cent., 4.8 per cent of ammonia was obtained, falling to 3.5 per cent on increasing the velocity to 20 liters per hour. With a velocity of 3 liters per hour at 550 deg. Cent. (120 atmospheres), 5.6 per cent of ammonia was obtained, rising to 5.85 per cent on reducing the velocity to 2 liters per hour. Good results were also obtained with uranium prepared by Moissan's method. An experiment extending over a long time with the commercial metal gave the results shown in the accompanying table.

The values marked with an asterisk were obtained not by determining the ammonia content at the given time with the interferometer, but by passing the gas during the interval between one test and the next through acid; they represent the yields corresponding to the mean of the values given in the same and in the succeeding horizontal series for the experimental conditions. It is important to heat up quite gradually in order to maintain the contact substance in an active condition. Experiments with uranium (pieces of the size of a pin-head) were also made in the simple steel cylinder, at a pressure of 125 kilos per square centimeter. With a velocity of about 32 liters per hour at 570 deg. Cent., 5.65 per cent of ammonia was obtained; 6.54 per cent at 505 deg. Cent., and 25.7 liters per hour; 9.1 per cent at 496 deg. Cent., and 9.5 liters per hour; and

Time Minutes	Temperature ° C.	Pressure Kilos. per sq. cm.	Velocity Liters per hour	Ammonia Per cent.
0	590	121	11	2.8
70	592	121	11	3.05
133	589	119.5	11	3.1
180	591	118	11	3.13
240	591	117	11	3.15
300	591	115.5	11	3.09
360	590	114	11	3.05
420	591	112.7	11	3.02
460	591	112	11	3.02
515	590	166	20	*2.85
613	594	157	20	*2.70
714	590	145	20	*2.50
823	(quite low at times)	131	20	*1.97
1093	ca. 590	118–115	20	*2.00
1118	590	156	20	2.68
1323	593	166	20	2.74
1333	590	165	10	3.60
1340	610	165	10	3.80
1348	609	164	20	3.00
1358	630	163	20	3.15
1365	608	162	5	5.05
1398	609	160	3	5.50
1428	590	158	3	5.50

11–11.9 per cent at 503 deg. to 493 deg. Cent., and 2 liters per hour.

Osmium.—Finely divided osmium proved a very effective catalyst. (In both the iron and chromium groups of metals, the metals of highest atomic weight possessed catalytic properties far superior to that o' the metals of lower atomic weight.) In a series of experiments with a layer of osmium 14 millimeters long and 4.5 millimeters diameter, 4.75 per cent of ammonia was obtained at 592 deg. Cent. and 156 atmospheres pressure and a velocity of 20 liters per hour. At the same pressure, 5.91 per cent was obtained at 572 deg. Cent., and 10 liters per hour; and over 9 per cent at 521 deg. Cent., 174 atmospheres, and 1.5 liters per hour. In a prolonged experiment with a small quantity of osmium (a layer 4 millimeters diameter and 1 centimeter long) 34 grammes of ammonia were obtained, and the contact substance was more active after 58 hours than after 3 hours. An experiment with gas circulation was carried out with osmium as catalyst. After pumping out air from the apparatus (see Fig. 4) the mixture of nitrogen and hydrogen was introduced up to a pressure of 185 atmospheres, and the circulating pump set working. A current was now sent through the heating wire (17–18 amperes at 56 volts). The temperatures registered by the three junctions of the thermo-element varied from 580 deg. to 635 deg. Cent. at that next to the heat regenerator, from 750 deg. to 825 deg. Cent. at the intermediate junction and from 880 deg. to 1,000 deg. Cent. at the first junction. At first the liquefier was not cooled, and the ammonia content of the gas-mixture rose to 5.4 per cent. The liquefier was then cooled with a mixture of alcohol and solid carbon dioxide and kept at —25 deg. to —39 deg. Cent., mostly —30 deg. Cent. The experiment was continued for 4 hours, the pressure ranging from 193 to 163 atmospheres. The ammonia content of the gas varied from 2.4 to 3.1 per cent, mostly 2.6–2.9 per cent. (Higher figures would have been obtained with a larger quantity of contact substance.) About 500 cubic centimeters of liquefied ammonia (corresponding to 336 grammes or 475 liters of gas at ordinary temperature and pressure) were obtained in the 4 hours. The heat and cold-regenerators acted very efficiently. The copper capillary through which the gases left the furnace could be held comfortably in the hand quite close to the furnace. The cold regenerator had a thick coating of ice on the side where the gases entered from the liquefier, while on the other side it was at the ordinary temperature. At the end of the experiment the residual gas mixture contained 30 per cent of nitrogen plus argon.

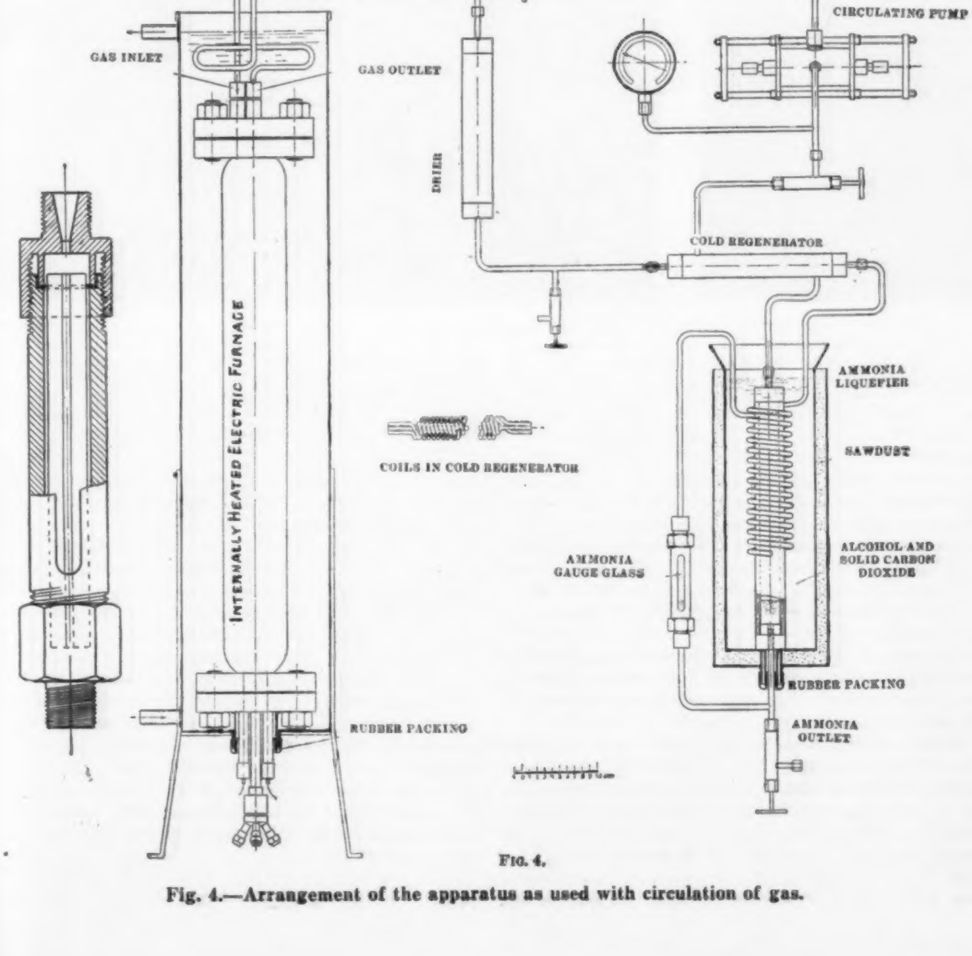


FIG. 4.

Fig. 4.—Arrangement of the apparatus as used with circulation of gas.

Removal of Fusions in Alkaline Carbonates from the Crucible

By R. Howden B.Sc.

If a pinch of powdered potassium nitrate be dropped into the crucible while the fusion is still red-hot and liquid, the evolved gases render the mass porous, and the whole can be removed from the crucible, by simple solution in hot water, in twenty minutes or less. It is well to give the crucible a circular movement so as to mix the nitrate well with the carbonates, and to spread the latter over the sides of the crucible.—*The Chemical News.*

The Voices of the Deaf*

Graphic Records of Speech

By E. W. Scripture, Ph.D., M.D.

THE first extensive researches with graphic records of speech were those of the Abbé Rousselot on one of the French dialects. Many further studies of French and other languages have come from his laboratory of experimental phonetics at the College de France. The method is available for the most varied researches on voice and speech in the various languages and dialects, on their modifications by defect and disease, on the peculiarities and troubles of singers, on the correctness of oratorical speech, etc. In short, there is hardly a problem of speech, from correcting a German's mispronunciation of English to the analysis of a maniac's ravings, to which this method has not or cannot be applied with profit. Strangely enough, no attempt has ever been made to apply it to the speech of the deaf.

FIG. 1.—Graphic records of the word "potato," spelled in phonetic notation (poteto). The small waves are the record of the vibrations of the voice during the vowels. The straight lines show where the breath was cut off by the occlusives "p" and "t." Each occlusion ends in an explosion, shown by the sudden rise of the line with the large vibrations. First line: normal record. Second line: record by C. F.: the vowels and the occlusions are too long and the explosions are long and breathy. Third line: spoken by C. F., after comparing his record with the normal one. Note the marked improvement as brought out by the similarity of the third tracing and the second. Except for a difference in speed there is almost perfect agreement.

FIG. 2.—First line: "too much" (tum v̌c), spoken normally. The occlusion and the explosion of "2" are similar to those in Fig. 1. The vibrations of "oo" are followed by the weak vibrations of "m." The strong vibrations of "u" are followed by the occlusion, with long fricative ending of "ch." Second line; record by A. O.; there is no explosion for "t"; the "m" is unvoiced; the word ends with an occlusion, namely, "t" without its explosion. Third line: record by A. O., after studying that in the first line; the initial "t" has an explosion; the "m" is not voiced; the final sound is "t," followed by "sh"; the entire record is exaggerated owing to over-enunciation.

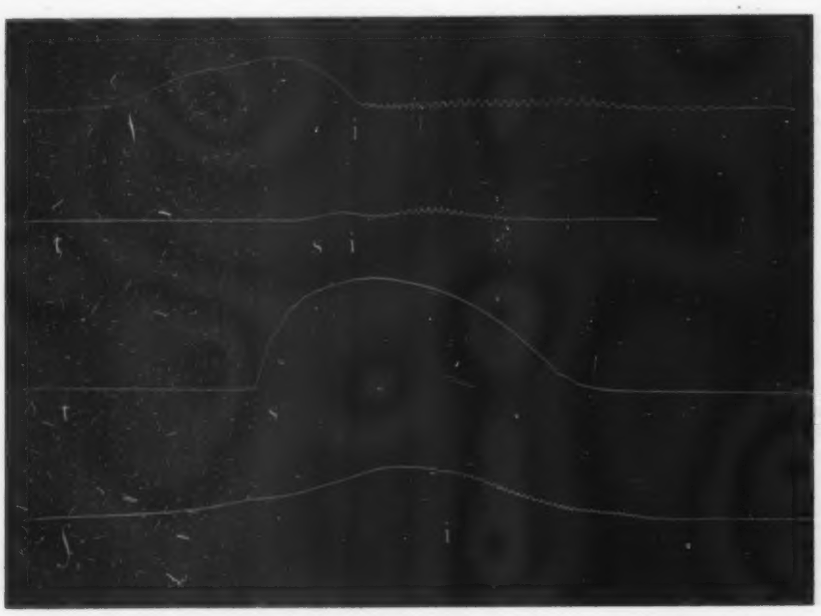


FIG. 3.—First line: record of "she" spoken normally, in phonetic notation (ʃi); during the fricative "sh" the line rises gradually. Second line: record by C. F., which sounded like "t_se" (t_si), with a very brief "s"; the straight line records the long occlusion for the "t"; the normal explosion for "t" (see Fig. 1) is lacking; it is replaced by a weak fricative sound indicated by the slight rise in the line. Third line: C. F. attempts to make "sh" like that in the first line; the result is "ts," the "s" being exaggerated. Fourth line: C. F. pronounces "she" correctly, except for making "sh" a trifle too long.

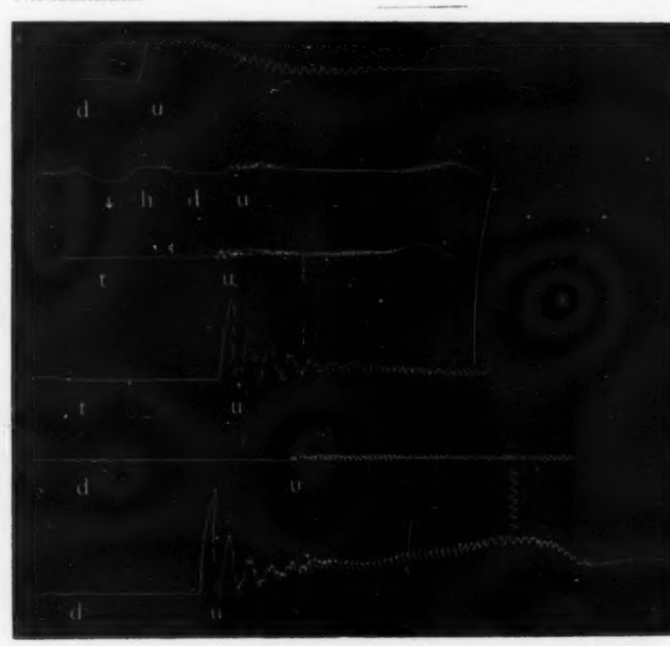


FIG. 4.—First line: "do" (du), spoken normally. Second line: last word of "How do you do?" by A. O.; instead of "d" there are a short inspiration, a short breath, and a short "d," without explosion. Third line: "do," by A. O.; the occlusion lacks vibration (it is unvoiced); it does not end with an explosion. Fourth line: A. O. succeeds in introducing an explosion after the occlusion, but it is still unvoiced. Fifth line: A. O. voices the occlusion, but omits the explosion. Sixth line: A. O. voices the occlusion fairly well; the explosion is too violent.

A sheet of glazed paper is fastened around a metal cylinder and is smoked over a gas flame. The cylinder is then placed on a clock-work (Fig. 6) that can revolve it rapidly and regularly.

The recording apparatus is shown in detail in Fig. 5. When a person speaks into the mouthpiece *E*, the vibrations and puffs of air pass down the rubber tube *D* to the metal tube *C*. A sheet of rubber *J* is tied over the end of the tube at *A*. A metal lever *L* is connected to the rubber by the link *K*. The vibrations and puffs of the voice are transmitted by the rubber to the lever. *G* and *G'* form an arrangement for placing the axle of the lever nearer to the link *K*; this regulates the enlargement of the vibrations. A vertical adjustment is obtained by *F*. The tube is held by a clamp to the heavy tube *H*. This is fastened firmly on a rod (Fig. 6) by the screw *I*. A long, light straw, with a fine horn point, is placed on the lever *L*.

This mouth recorder, devised by Rousselot, is the best of any I have used. It is advisable to use a long rubber tube between the recorder and the mouthpiece.

When a record is to be made, the drum is wound up and set in motion. A tuning-fork of 100 vibrations a second is held so that a fine point or bristle on the end of one of the prongs touches the smoked surface. This draws a wavy line, each wave of which measures 1/100th of a second (Fig. 7). The speed of the drum is thus always known. The point of the recorder is then placed to the drum. The person speaks the desired words and the recorder is moved away.

The top line of Fig. 1 gives a record of "potato," spoken normally. It begins with a straight line, due to the occlusion of the "P"—that is, to the period during which the breath is stopped by the closure of the lips. The sudden movement of the line upward is due to the explosion of the "P" as the lips are opened. The explosion is so sharp that the lever makes several large vibrations before it comes to rest. The small waves are a record of the vibrations of the vowel "O." These are suddenly cut short and the line drops for the occlusion of the "t." The "t" has an explosion, but it is not so strong or so sharp as that of the "p." The small waves that follow are a record of the vowel "a." The second "t" has an occlusion somewhat shorter and an explosion somewhat sharper than those of the first "t." The word ends with the vibrations of the vowel "o." In the figure the lettering is in the international phonetic alphabet; the sound of the second vowel is indicated by "e."

The second line of Fig. 1 gives a record of the same word by C. F. (15 years of age, totally deaf

* Reproduced from the *Volta Review*.

since 7 years of age, under oral instruction for 8 years). We notice in the first place that the word was spoken far too slowly. By applying dividers, or a scale, to the last vowel, "o," we find that it is fully twice as long as it should be.

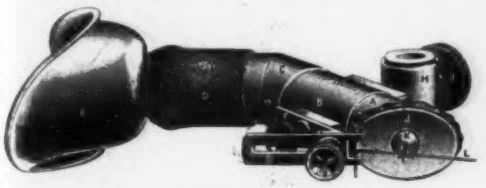


Fig. 5.—Mouth recorder, top view.

This last fact was explained to C. F., whereupon he made the record shown in the third line of the figure. In the effort to correct his drawl he made the vowels even a little shorter than the normal ones. Comparison of line 3 with line 2 shows that the explosions of the "p" and the two "t's" were made quickly and snappily instead of breathily, as in line 2.

The same pupil was asked to read from a book. The pronunciation of "she" seemed peculiar. He was asked to make a record. The result is shown in the second line of Fig. 3. A normal record was then made (first line of Fig. 3) and shown to him. He at once understood that he did not emit breath enough for the consonant, so he tried that alone. The result is given in the third line. He had no difficulty in understanding that he had first made an occlusive (namely, "t") and then put a fricative after it instead of producing a fricative alone. A further attempt is shown in the fourth line. The fricative sound is somewhat too long, but otherwise it is correct. One other fault was involved in his pronunciation, namely, the use of "s" for "sh." He first said what sounded like "tse" (tsi). He had made a "t"-sound with an "s"-like explosion. After the record in the third line he was told not to say "s" but "sh."

The first line of Fig. 2 shows a normal record of "too much." The occlusion of the "t" and its explosion are followed by the vibrations of the first vowel. The line for the "m" is at the zero level, because the lips are closed and no air issues; there are faint vibrations, because "m" is voiced.

Fig. 7.—Time line; each vibration measures 1/100th

The vowel "oo" is registered by strong vibrations. The line falls suddenly as the tongue closes the mouth passage for "ch;" it rises and remains up a while for the last part of "ch." We note that the record of "ch" consists of an occlusion, followed by a breathy sound.

Fig. 6.—Graphic records of speech. The apparatus in use, showing the strawpoint tracing a record on the rapidly revolving cylinder.

The second line of Fig. 2 shows a record of "too much" by A. O. (17 years old, totally deaf since birth, under oral instruction for 4 years). The initial "t" had no explosion and the last sound was a simple occlusion, like a "t" without the explosion. The normal record was explained to him. After half an hour's practice he made the record shown in the third line. The initial "t" has a highly exaggerated explosion. For "ch" he has an occlusion, followed by a fricative sound, but the change from the former to the latter is too sudden. This occurred because he used the front-shut instead of the top-shut position of the tongue for the first part of "ch" and also because all his speech movements were exaggerated. The correction of his over-enunciation and of the voiceless "m" (shown by lack of vibrations in the records) was reserved for another occasion.

It was noticed that instead of "How do you do?" A. O. said something that sounded like "How ho hou ho?" The record of the last word, "do," spoken normally, is shown in the top line of Fig. 4. The occlusion, the explosion, and the vowel waves are clearly marked. The record of the last word in the phrase spoken by A. O. is shown in the second line. It shows a brief fall in the line, due to a slight inspiratory gasp which he was accustomed to make. This is followed by a slight rise in the line that records a short and rather weak "h." The "h" ends in some vibration. The following piece of straight line, with faint vibrations, corresponds to a correctly made occlusion for "d." The record indicates the nature of the boy's mistake. Instead of ending the preceding vowel by closing the tongue against the palate, he inspires through his mouth, blows out a short "h," starts his larynx vibrating, and only after all this does he use his tongue for "d." out a short "h," starts his larynx vibrating, and

The record of normal "do" in the first line was then shown to him. His attempt at this word alone is shown in the third line. The occlusion of the "d" is present, but there are no vibrations and there is no explosion; the sound was rather a "t," with no explosion. The vowel vibrations are correctly made.

It was easy to get him to make an explosion for the "d" (fourth line), and fair success was achieved in introducing voice (fifth line). The best record obtainable in the half hour at disposal is shown in the fifth line. The "d" is not perfectly voiced and its explosion is exaggerated.

This method is of such practical value that it will probably be introduced in many places. In using the apparatus, the recording drum must run so rapidly that the surface of the smoked paper travels at the rate of at least 100 millimeters a second. Its speed must be very regular.

To smoke the drum it is removed from its axle and placed on a special support. A sheet of glazed paper, gummed on one end, is placed around the drum. A gas flame is held closely under it while it is turned rapidly.

The Principles of Fuel Oil Engines—II*

The Chemical and Physical Bases of Their Operation

By C. F. Hirshfeld

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1959, July 19, 1918, Page 47

We will now leave the matter of vaporization for a time and consider the various fuels with which we are to deal. These fuels are either complex mixtures of hydro-carbons with widely differing properties or they are less complex distillation products made from such a mixture. One important thing to be noted is that no real petroleum fuel is a single chemical compound but that even the simplest is a mixture of such chemical entities.

Another very important item is the fact that the crude petroleums obtained from different fields vary greatly in chemical and physical characteristics. This same statement applies in a general way to the distillation products obtained from the different crude materials, but it should be noted in this connection that certain physical tests may be made to give the same results on materials which are really very different.

These differences are not merely of academic interest, but have a very practical bearing on the use of at least some of the fuels in internal combustion engines. No builder of an engine intended to use heavy fuels, for instance, should be satisfied that his engine is commercially perfect if he has tried it out only with Pennsylvania petroleum. In many cases he would discover that its action with California oils would leave much to be desired.

The common methods of testing and describing petroleum fuels are entirely physical and therefore give only part of the information which is desirable. Thus we determine specific gravity, flash and burning points, and the results of fractional distillation, and most of the engineer's knowledge is based upon such information. It follows, therefore, that we often obtain anomalous results when chemical properties vary greatly although the physical properties are about alike.

It is customary, though far from correct, to assume that the petroleum products consist of mixtures of the various members of the methane or paraffine series of hydro-carbons. The nearer they approach this condition the simpler is their refining and the better their operation in the internal combustion engine. Pennsylvania oil approximates this ideal more closely than do the oils from the western States and the latter therefore offer greater difficulties in utilization.

For the purpose of obtaining a simple analysis we will start with this incorrect assumption, but the fact that we do so must not be forgotten and due allowance must be made later.

METHANE OR PARAFFINE SERIES. C_nH_{2n+2}.

Name.	Melt. Temp. F.°	Boil. Temp. F.°
Methane CH_4	Gas	Gas
Ethane C_2H_6		
Propane C_3H_8	"	—48°
Butane C_4H_{10}	"	+33°
N-Pentane C_5H_{12}	Liquid	100
Iso-Pentane	"	86
N-Hexane C_6H_{14}	"	156
Iso-Hexane	"	141
N-Heptane C_7H_{16}	"	207
Iso-Heptane	"	196
N-Octane C_8H_{18}	"	257
Iso-Octane	"	244
N-Nonane C_9H_{20}	"	303
Iso-Nonane	"	266
N-Decane $C_{10}H_{22}$	"	339
Iso-Decane	"	320
Endecane $C_{11}H_{24}$	"	359
Dodecane $C_{12}H_{26}$	"	392
Tridecane $C_{13}H_{28}$	"	426
Paraffines (to $C_{30}H_{62}$)	140°	698

Fig. 2a.—Melting and boiling points of methane series.

* Paper read before the American Society of Agricultural Engineers and published in the *Gas Review*.

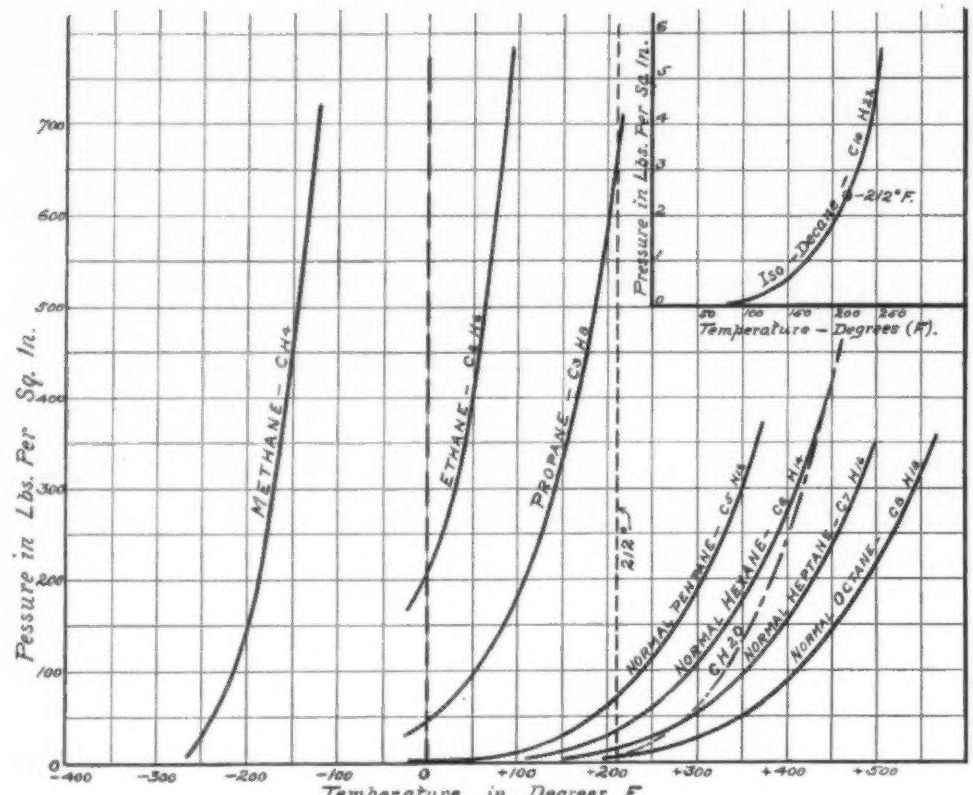


Fig. 2b.—Vapor pressure curves of a number of pure hydrocarbons.

In Fig. 2*a* is given a list of the members of the methane series together with their melting and boiling points. Fig. 2*b* gives curves showing the variation of vapor pressures with temperature for the simpler members of the series, the data not being available for the more complicated compounds. These vapor pressure curves are exactly like the curve we have already considered in the case of water and can be used for determining the boiling points or temperatures under any pressure. In fact, these curves read boiling temperatures directly if we simply change the label on the horizontal axis to read boiling temperatures.

It will be observed that only the lighter members of the series boil at temperatures below atmospheric and that few of them boil below a temperature equal to that of boiling water. These curves thus enable one to form some sort of a concrete idea as to the relative volatility of the various members of the series.

For purposes of comparison with real fuels the curves given in Fig. 2*c* may be used. The gasoline curve is for a sample of about 66 deg. B. gravity. The curve indicates that this material would boil under atmospheric pressure at a temperature of about 145 deg. Fahr. so that in this respect it resembles pentane and hexane. The kerosene curve is for material of about 45 deg. B. and it indicates that at a temperature of 175 deg. Fahr. the vapor pressure of this fuel is only about 0.14 of an atmosphere; that is, it is still far from the temperature of ebullition. It resembles in a general way the compounds in the neighborhood of tetradecane.

In Fig. 2*d* are given constants for the ethylene or olefine series. It will be noticed that the members of this series resemble in a very general way the members of the methane series. There are, however, very marked chemical and physical differences, and it is probably due to the presence of some of these olefines in our heavier fuels that we get certain undesirable phenomena.

In Fig. 3*a* are given the volumes occupied by the saturated vapors of the methane series together with their boiling points. The volumes have all been reduced to a basis of 32 deg. Fahr. despite the fact that the vapors would not exist at this temperature. This is the common method of tabulating such values and need cause us no concern as we are interested only in relative values. The diagram shows that as the molecules become more complicated, and therefore heavier, the volume occupied by one pound of saturated vapor decreases. This result could, of course, be predicted from Avagadro's law, but it is of such great importance that it is best to call attention to it in this graphical way.

We have now noted the low vapor pressures of the more complicated members at ordinary temperatures as shown by their high boiling points and have also observed the decreasing volume of the vapors as we pass in the direction of greater complication. We must next consider the amount of air required to burn the various members of the series. The diagram of Fig. 3*b* is plotted for this purpose. It indicates the relative volumes of saturated vapor and air required (theoretically) for combustion. It will be observed that the relative volume of air increases very rapidly as the molecules become more complicated.

It should also be noted that all the air volumes given are very great in comparison with those needed in the case of gases as shown in Fig. 3*c*.

In the actual operation of engines these differences will be still more marked because while gases require only about 25 per cent to 30 per cent excess air, liquid fuels of the heavier varieties require from 50 per cent to 100 per cent excess.

We will now consider the real fuels with which we are concerned. These are crude petroleum and the refinery products ranging from gasoline through the kerosenes and distillates to residuum, or material left after distilling off the more volatile parts.

As already indicated, these are all mixtures, the crude containing, in general, the greatest number of different compounds. Gasoline and kerosene are, however, generally fairly complex mixtures, as will be shown later.

To illustrate the complexity of structure, curves of fractional distillations may be used. These are obtained by raising known quantities to successively higher temperatures and measuring the amount distilled off at convenient intervals. Such curves are given in Figs. 4*a* and 4*b*.

The names of the members of the methane series are added to these curves at points corresponding to their boiling points and serve to indicate in a rough way the complexity of the molecules making up the different mixtures.

The curves in Fig. 4*b* are of particular interest as they are for one variety of crude and the various distillates made from it.

From these curves it is evident that the distillates are, in general, less complicated than the crude materials and contain a lesser number of compounds. This would lead one to expect them to give less trouble in an engine and this is true in a general way.

It is, however, important to note that a distillate of a certain gravity and with a certain average boiling point is by no means always the same sort of material. For instance, a gasoline of a certain gravity may contain practically only one material with that gravity, or it may be made up of lighter and heavier materials in such proportions as to average the desired gravity. The best way of determining this sort of thing is to fractionally distill; the simpler fuel will give almost a horizontal line while the more complex article will give a sloping line on the chart.

The flash point test can also be used to indicate the quality of a distillate, but the indications are merely of an inferential character and more experience is required in interpreting them.

Let us now look at the various methods of utilizing liquid fuels in internal combustion engines and see what

ETHYLENE OR OLEFINE SERIES. C_nH_{2n}.

Name.	Melt. Temp. F.°	Boil. Temp. F.°
Ethylene C_2H_4	Gas	Gas
Propylene C_3H_6		
Butylene C_4H_8	"	+33
Amylene C_5H_{10}	Liquid	103
Hexylene C_6H_{12}	"	156
Heptylene C_7H_{14}	"	209
Octylene C_8H_{16}	"	257
Nonylene C_9H_{18}	"	283
Decatylene $C_{10}H_{20}$		
Endecatylene $C_{11}H_{22}$		
Melene $C_{30}H_{60}$		

Fig. 2d.—Melting and boiling points of ethylene series.

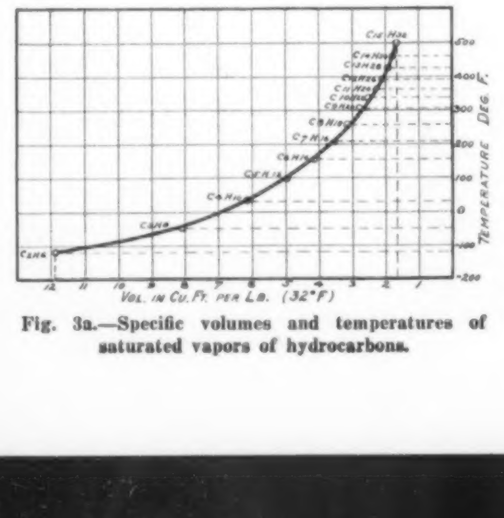


Fig. 3a.—Specific volumes and temperatures of saturated vapors of hydrocarbons.

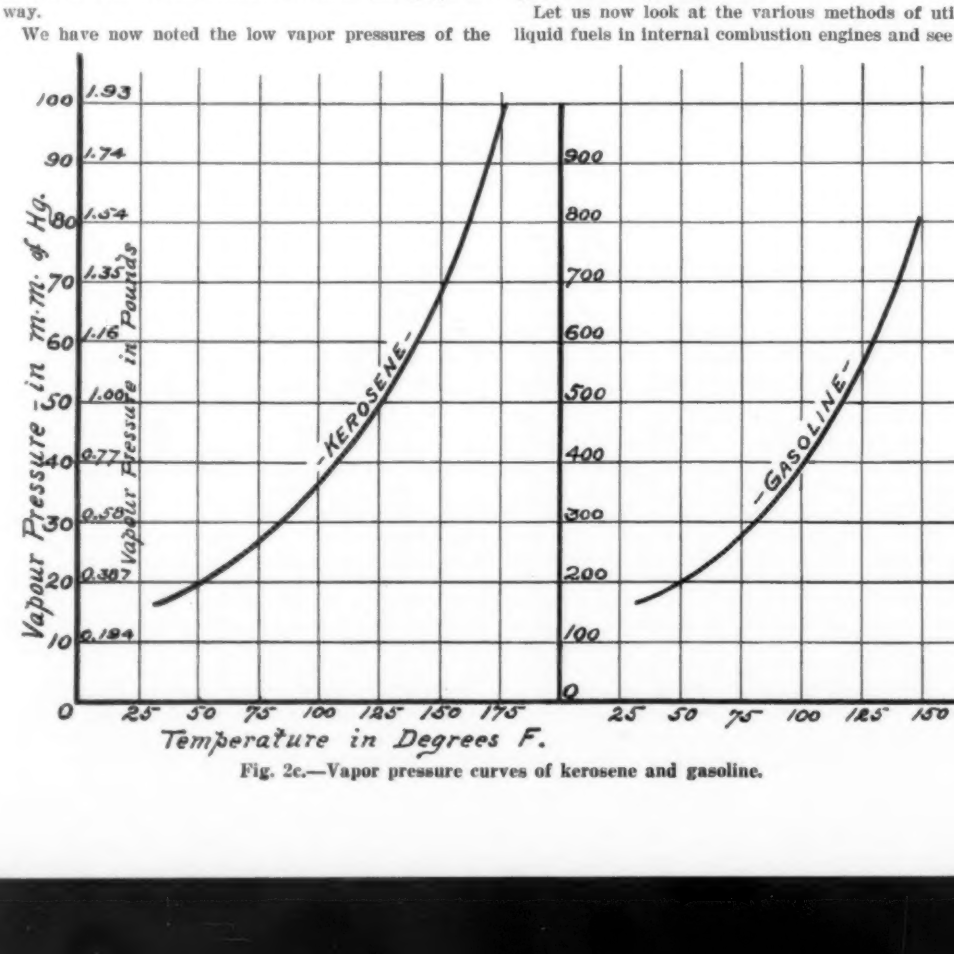


Fig. 2c.—Vapor pressure curves of kerosene and gasoline.

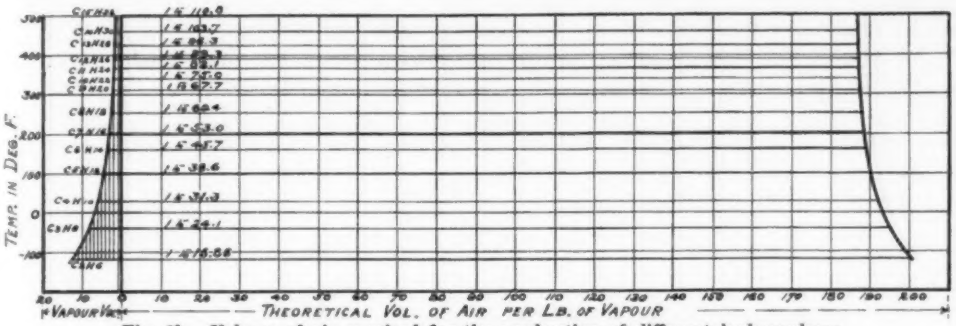


Fig. 3b.—Volume of air required for the combustion of different hydrocarbons.

conclusions we can draw. One very important fact must be remembered in all that follows: liquid hydrocarbons will not burn in the liquid state, but must first be vaporized. The apparent contradiction with which most of you are probably familiar, namely, the burning of heated liquid, is not really what it seems. The liquid does not burn, but the heat generated by the burning of vapors above the liquid vaporizes that liquid rapidly enough to keep up a continuous supply of vapor.

The methods in use with liquid fuels are divisible into two distinctly different varieties and each of these is in turn divisible into two kinds. This is shown by the following schedule:

Methods
- External preparation, fuel
  - Without water
  - With water
- Internal preparation, fuel
  - Without water
  - With water

We will start our study with the first subdivision under the first method and the consideration of the others will follow in the way best suited to bring out ideas as they develop.

The simplest example of the type we have chosen to start with is illustrated in Fig. 5*b*. Liquid fuel is sprayed into the air as it enters the engine. That is, we duplicate the conditions of vaporization assumed in Fig. 1*c* and pass drops of liquid through the air which is to be mixed with the vapors generated. With a gaseous fuel such a mixing method would be very satisfactory and it works well with the more volatile gasolines. It would work well with gases because the volume of air through which the gas molecules must diffuse is comparatively small and the rate of diffusion of the gas molecules is great. Even in the worst cases a satisfactory mixture can therefore be formed in the small time available. With very volatile gasoline the conditions are not quite so propitious, but they are nevertheless sufficiently favorable to insure satisfactory operation. With such gasolines the most voltatile constituents boil at temperatures below 100 deg. Fahr. and the least volatile parts boil in the neighborhood of 200 degrees. This indicates that the vapor pressures of many of the constituents are near atmospheric at ordinary pressures and hence the liquid vaporizes very readily.

When such material is sprayed into the ingoing air there must be rapid vaporization from the surface of the drops and during the later compression the rise of temperature is sufficiently great to make any remaining liquid flash into vapor. The quantity of air through which the molecules must diffuse is less than for any of the other petroleum fuels and the molecules of vaporized fuel are lighter and diffuse faster than do those of the heavier hydrocarbons, so that the formation of a satisfactory mixture is not very difficult.

With heavier gasolines, conditions are not so favorable and when we come to consider kerosene we meet an absolutely different state of affairs. The least volatile constituents of the latter fuel do not boil below a temperature of about 600 deg. Fahr., and the most volatile must be raised to about 300 degrees. It is obvious that vaporization of this fuel in air of ordinary temperature will be very slow in comparison with the gasoline we have just considered. It can be expedited by very fine spraying and by heating the oil, or the air, or both. If the metallic surfaces with which the mixture comes in contact are also maintained at a high temperature this will help.

We might by such expedients succeed in forming a satisfactory vapor in the time available and we might be able to overcome the slower rate of diffusion into the larger quantity of air by providing mixing devices such as a spiral in the inlet passage. There are, however, other things which must be considered.

Most important among these is the tendency of the heavier hydrocarbons to crack, that is, to decompose chemically to form other compounds. In general, cracking will result in the formation of molecules simpler than those which cracked and of more complex molecules, or in extreme cases pure carbon. The resulting molecules are generally not all of the same series, so that if we crack paraffines we generally get lighter paraffines together with olefines or members of other series.

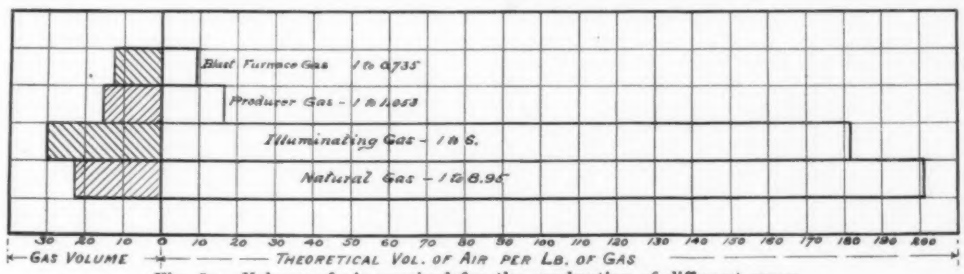


Fig. 3c.—Volume of air required for the combustion of different gases.

Cracking is not very well understood, but it is known to occur whenever a petroleum oil is distilled at a temperature higher than the normal boiling points of the constituents being distilled off. It is greatest in amount when the distilled vapors are returned to the hot liquid several times before finally escaping.

Commercially it is used in refineries for the production of a larger quantity of light liquids than would normally be obtained from the oil being distilled.

Cracking does not, in general, occur to any appreciable extent at temperatures below about 600 deg. Fahr. under the conditions which have been studied, and it is probable that at least this temperature must be reached inside of an engine cylinder before any great amount of cracking will occur.

Let us now return to the consideration of an engine fitted with a jet carburetor and using kerosene. During compression the temperature of the mixture in the cylinder will probably be raised to an average value above 500 deg. Fahr. if the charge is drawn in at atmospheric temperature and any higher temperature can be attained by raising the initial temperature. Since the average temperature must be made up of a balance between a low value in contact with the walls and a higher value at the uncooled core of the charge it is obvious that conditions near the end of the compression stroke are such as to cause incipient cracking of vapors near the center of the charge. The larger the engine the less will be the cooling at the center of the mixture and hence the greater the danger of cracking.

If we are particularly fortunate and use a small cylinder with well-cooled walls and low compression we may be able to vaporize and compress without any cracking, but with desirable wall temperatures, efficient compression ratios, and commercial speeds such conditions are practically impossible of attainment. It must be recognized that there are two antagonistic

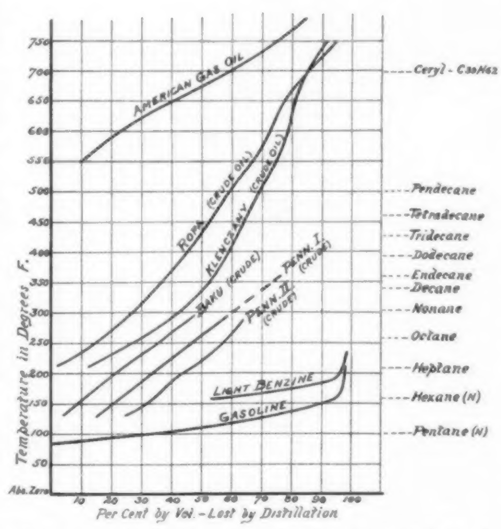


Fig. 4a.—Distillation curves, showing complexity of commercial products.

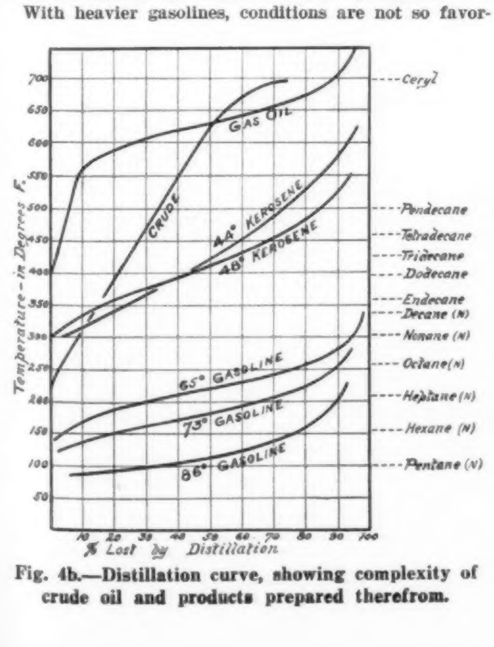


Fig. 4b.—Distillation curve, showing complexity of crude oil and products prepared therefrom.

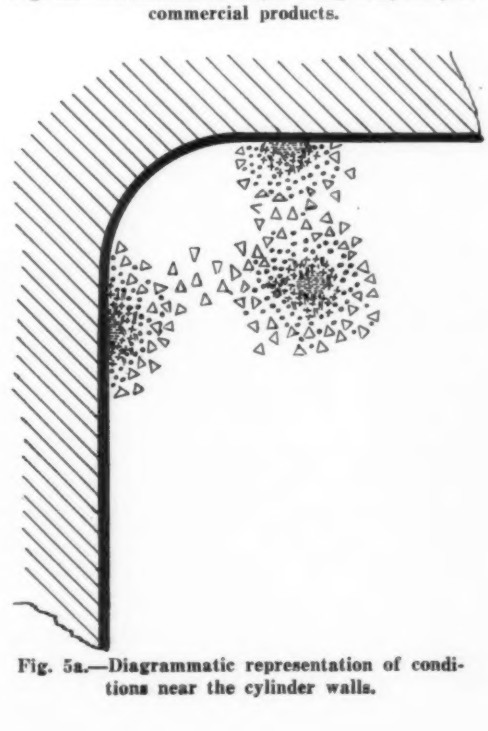


Fig. 5a.—Diagrammatic representation of conditions near the cylinder walls.

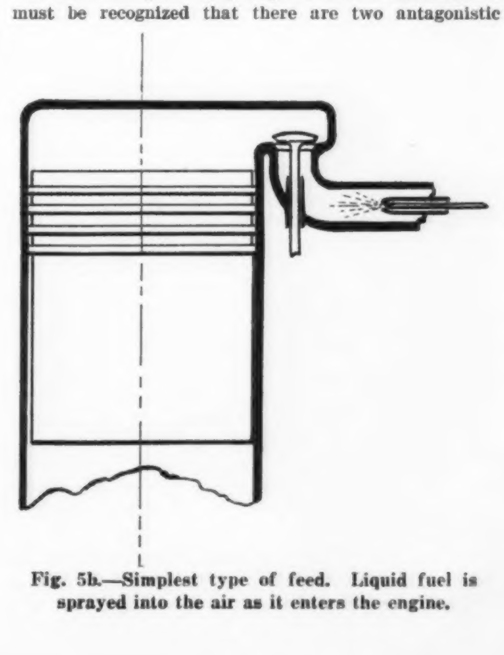


Fig. 5b.—Simplest type of feed. Liquid fuel is sprayed into the air as it enters the engine.

requirements; the walls and the mixture must be at high temperatures to expedite vaporization, but they must also be at low temperatures to prevent appreciable cracking during compression.

With ordinary wall temperatures there is nearly always a deposition of liquid on the walls and there are generally drops of liquid suspended in the body of the charge even at the end of the compression stroke. Such drops will, of course, be covered by a dense blanket of their own vapor. Outside of this blanket will be successive gradations of mixed vapor and air. If combustion now occurs the drop and its vapor blanket will become surrounded by burned gases which are obviously at a very high temperature. Before the vapor can burn further these gases must be moved away and fresh air brought up into contact with the vapor, but while this is occurring the vapor and the drop are both subjected to temperatures far in excess of 600 degrees. Cracking will therefore occur at a rapid rate and will be so complete as to result in the deposition of carbon and the formation of very heavy molecules which will later be recognized as tar or pitch when they have had a chance to cool down.

This is illustrated in Fig. 5a, in which the horizontal dash lines represent liquid, the crosses represent unburned vapor, the solid circles burned gases, the triangles unused air, and the double vertical dashes deposited carbon.

Since increase of temperature of walls and charge before induction will only make cracking start earlier, it is not the proper remedy for imperfect vaporization. There are, however, other means available and they should be used to a greater extent than is now the case. Extremely fine spraying will not only increase the rate of evaporation as already shown, but will make any drops of liquid which remain at the time of combustion so small that there can be no appreciable amount of cracking before they are completely vaporized and burned. Extremely fine spraying will also distribute the material more or less uniformly through the air and thus decrease the difficulty of making vapor and air meet as necessary for combustion, so that fine spraying counteracts the naturally low rate of diffusion of the heavy vapors. The addition of means for mixing will also help. These must generally be based upon the idea of giving the mixture a turbulent motion as it is introduced into the cylinder.

Kerosene is further handicapped by certain properties which show themselves commercially in two ways. These are:

1. If high temperatures of wall or charge are used, if compression is carried to a high value, or if vaporization is made very perfect, the engine gives trouble because of frequent preignitions which are apparently due to auto-ignition, and

2. An engine which runs perfectly smoothly and with clear exhaust at low and medium loads will pound violently when run at higher loads.

These phenomena can be tentatively explained in the following ways:

So far as experiment has gone it proves that the heavier molecules of the methane series form mixtures which ignite at lower temperatures than do the lighter mixtures and also that the other series have lower ignition temperatures than do the paraffines. As kerosene always contains some of the heavy paraffines and members of the olefine series as well, it is apt to form vapors which will ignite at a low temperature. It seems probable that there are small quantities of hydrocarbons of many other series present as well as the constituents just mentioned and certain experiments indicate that there may be acetylene present or formed during compression. If this is true, early ignition is easily explained.

When it is remembered that most kerosene engines accumulate more or less carbon and that this material generally remains incandescent within the engine cylinder it is still easier to account for preignitions of the very easily ignited vapors formed within the cylinder.

Further, certain of the hydrocarbons share with hydrogen the property of transmitting flame very rapidly, that is, they give mixtures for which the velocity of flame propagation is high. It is probably due to the presence of such hydrocarbons and of hydrogen, largely resulting from cracking, that the sudden pressure rise occurs when an engine is running under high load. They serve to rapidly inflame the entire mixture so that it burns in the minimum time and therefore gives maximum pressure rise. When operating at light loads, governing is sure to result in one of two things: either the total quantity of charge is decreased, or else the quantity of fuel in the charge is lessened. In the first case, compression pressure and temperature are lowered and both cracking and velocity of flame propagation are lowered so that the operation will be smoother. In the second case the mixture is more dilute than when operating at full load and the velocity of flame propagation is low.

Looking at the matter from another angle: when approaching full load conditions, compression pressure, operating temperature, and composition of mixture all tend toward the values which will give highest velocity of flame propagation, highest pressure with which to start pressure rise, shortest time for loss of heat to jacket. Hence it is reasonable to expect an engine to give trouble by pounding when operating at high loads.

(To be continued)

Sunstroke

Two totally dissimilar conditions are usually included under the ordinary generic term sunstroke, and a study of either or both of them shows that sunstroke as a descriptive term is a misnomer. For popular use, however, it would be difficult to find as terse and suggestive a substitute.

The milder disease is sometimes and properly called "heat exhaustion." It occurs most frequently in women who, from improper feeding, or underfeeding, or a sedentary life, have a feeble circulation. Tight lacing frequently precipitates an attack by preventing the radiation of heat from the trunk, and simultaneously displacing and interfering with the motion of the heart. The condition is essentially a syncope. The intense heat of the atmosphere induces profuse perspiration, the blood-vessels of the skin are relaxed, dilated, and overfull, especially the veins, and it is probable that the vessels of the abdomen are also relaxed, and contain an abnormal quantity of blood. The consequence of these conditions is that an insufficient supply of blood is available for the nourishment of the brain. The heart attempts to compensate for this by increased rapidity of action. Hence, a sensation of a want of breath, increased rapidity of respiration, exhaustion of the laboring heart, and a "dead faint;" that is, syncope with unconsciousness. The treatment is obvious; a recumbent position, elevation of the legs above the level of the trunk and head, loosening of the clothes so as to give the lungs and heart full play, which is fair play, and the use of a temporary diffusible stimulant, such as the inhalation of ammonia vapor, until perfect consciousness returns. Thereafter, rest until the patient can partake of a small quantity of easily-digested and nourishing food (in those cases where nourishment is necessary), the attack being regarded as a warning to improve the patient's condition as to kind and quantity of food, hours and conditions of work, temperature and ventilation of bedroom, and overweight and constriction of clothing.

THE SECOND CONDITION.

True sunstroke, as it has been called, is a much more serious matter, and practically, invariably, when the immediate attack has been recovered from, and the mortality is very high, leaves evil effects behind it which cripple the individual for years, perhaps for a lifetime. True sunstroke occurs more frequently in men, and not necessarily in those whose occupation exposes them to the direct rays of the sun. The victims are found almost exclusively among those members of the community, in all classes of society, who add to over-indulgence in alcohol (not necessarily meaning the drunken) indiscretions in diet, such as is involved in eating the average saloon free lunch of acidified vegetables and highly putrescible meats infected by flies of unknown antecedents. Two hot, sleepless nights have occurred, the individual, usually innocent of any knowledge of hygienic laws, has attempted to assuage thirst by glasses of cold beer or colder whisky put into the stomach at irregular intervals. Food with little food value, but great possibilities of harm, is also taken irregularly. There is probably constipation, profuse perspiration, and diminishing excretion of urine, when suddenly the acute attack occurs. The usual picture is that of a man in more or less violent convulsions, face congested, eyes suffused, skin of the body intensely hot, dry, and of a waxy pallor. The temperature, frequently 106 degrees to 108 degrees, sometimes rises as high as 112 deg. Fahr. to 114 deg. Fahr. The pulse, at first full and bounding, presently begins to fail, and finally the heart is only driven by the most powerful stimulants. A diarrhœa is present almost from the first, and its intensely fœtid character betrays the unspeakably virulent fermentations and ptomaine formation going on in the intestinal canal. The function of the kidney is suspended. The condition is essentially a ptomaine poisoning superinduced, in an individual whose habits make him susceptible, by the exhaustion, indigestion, and infected food incident to a hot wave passing over a city.

The old method of treatment of these cases was to pack the patient in ice in a bath-tub, and practically let it go at that. A close examination of the clinical facts has brought more rational management; first introduced, according to the writer's information, in one of the sugar refineries of Philadelphia. Immediately upon the determination of the condition, and diagnosis is easy and rapid, fortunately, the patient is stripped, and placed upon a stretcher in an apartment whose floors will readily drain off the abundance of water that is to be used. Ice-water flows from a large tank through a hose equipped with an ordinary "rose" sprinkler. The fall should be sufficient so that the body may be sharply whipped by the tiny streams flowing from the "rose." Presently the waxy skin begins to blush and glow, and the large volume of blood rising to the surface to flow rapidly through the skin is cooled by the ice-water with which it is almost in contact, and the body temperature, which is extremely destructive to the delicate nervous system, begins to fall. The head is packed in ice. The bowels are washed out repeatedly with ice-water, thus serving the triple purpose of cleansing the colon of its contained poisons, reducing the high temperature, and furnishing fluid to dilute the blood and relieve the poisoned brain and kidneys.

Statistics are difficult to obtain; but it is certain that many lives are now saved that formerly were lost.—*The English Mechanic and World of Science.*

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